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Continuous Motion Picture Projector for Use in Television Film Scanning

By A. G. JENSEN, R. E. GRAHAM and C. F. MATTKE

The projector used for this equipment drives a 35mm motion picture film at the standard (nonintermittent) speed of 24 frame/sec and produces a television signal of 525 lines and 30 frames interlaced 2 to 1. The projector utilizes a system of movable plane mirrors mounted on a rotating drum and controlled by a single stationary cam. Vertical jitter in the television image is minimized by means of an electronic servo system operating on the film sprocket holes, resulting in a residual vertical motion of about 1/2000 of a picture height. A second electronic servo system is incorporated to suppress flicker. The combination of this scanner and a high-grade monitor is capable of producing a television picture with a resolution corresponding to about 8 mc and with good tone rendition over a range up to 200 to 1.

THE PROBLEM of designing a motion picture projector, in which the film motion is continuous, has occupied inventors and designers almost since motion pictures first made their appearance. In the early days of motion pictures the need for a continuous projector stemmed largely from a desire to decrease the wear and tear suffered by the film in the intermittent projector. Later on, with the advent of sound pictures, it was felt that a continuous projector could fit in better with a machine in which the film had to move continuously through the soundhead.

Many different types have been proposed and patented but very few of them have gone beyond the experimental stage. A measure of the interest in this problem may be obtained from the bibliography at the end of this paper in which are listed the more important papers published on the subject during the years 1920–1945.

One particular type of continuous projector, the Mechau projector, did reach the commercial stage and was used in a limited number of German motion picture theaters in the 1930's.[1] This projector used eight movable mirrors, the motion of each mirror being con-

Presented on October 15, 1951, at the Society's Convention at Hollywood, by A. G. Jensen, R. E. Graham and C. F. Mattke, Bell Telephone Laboratories, Murray Hill, N.J.

[1] L. Burmester und E. Mechau, "Untersuchung der mechanischen und optischen Grundlagen des Mechau-Projektors," *Die Kinotechnik, 10:* 395–401, 423–426 and 447–451, Aug. 5, Aug. 20 and Sept. 5, 1928.

trolled by its own individual cam of rather intricate design. The mechanical portion of this machine is rather complicated and expensive and is difficult to keep in good running order. However, the machine has high light efficiency and, when properly serviced, does produce high-quality pictures.

With the coming of television the need for a satisfactory continuous projector again became apparent. Such a projector would lend itself admirably to translating the 24-frame/sec film picture into a 30-frame/sec television picture as called for by the present television broadcasting standards. In a continuous projector the motion of the film frames is in effect frozen in some image plane, and in this image plane it is then possible to scan the picture 30 times per second, or at any other desired rate, synchronous or nonsynchronous, for that matter. The British Broadcasting Company realized this many years ago and installed a German Mechau projector as a film scanner in their Alexandra Palace studio. One or more of these Mechaus are still being used for that purpose in London.

In the U.S.A. present commercial film scanners use a 24-frame/sec intermittent drive in combination with a storage-type camera tube such as an iconoscope. Very short, intense light pulses are flashed through the film frame onto the storage mosaic, which is then scanned between light flashes at 60 fields per second, interlaced, making 30 complete television pictures per second. Thus every other film frame is scanned twice, and the remaining frames, three times.

Unfortunately the iconoscope does not have a very good contrast range and inherent in the storage action are certain spurious signals which must be eliminated by introducing so-called shading or compensating signals, a fact which further tends to degrade the contrast. The result is that presently produced television signals from motion picture film are generally not as satisfactory as good direct pickup pictures.

In the Bell Telephone Laboratories there has been a need for high-grade television signals ever since the first development of wide-band television transmission facilities around 1935. Such signals are needed for test purposes and for determining the fundamental transmission requirements for components of wide-band circuits such as the coaxial cable and the microwave link. For this purpose several film scanners have been developed in the past.

The first of these was used to demonstrate the transmission of 240-line, 24-frame television signals over the early New York-Philadelphia coaxial cable in 1937.[2] It was a mechanical scanner using for the scanning unit a 6-ft disk with 240 lenses mounted along the periphery and rotating at 1440 rpm.

As the requirements for good definition went up, mechanical scanners became impractical, and a new electronic film scanner was developed and first used in the transmission of 441-line, 30-frame (60 fields interlaced) television signals over the later New York-Philadelphia coaxial cable circuit in 1941.[3] This film scanner employs specially prepared 60-frame/sec motion picture film, continuous film motion, and a Farnsworth dissector tube, which is a nonstorage device. The continuous motion of the film furnishes the vertical scan for the pickup so that only a horizontal scan is required of the dissector tube. The equipment has since been redesigned to produce 525-line, 30-frame pictures as presently standardized, and was used for transmitting television signals over the New York-Boston microwave relay in 1947. The pictures from this scanner show very good detail and a wide range

[2] M. E. Strieby, "Coaxial cable system for television transmission," *Bell System Tech. J.*, *17:* 438–457, July 1938.

[3] A. G. Jensen, "Film scanner for use in television transmission tests," *Proc. IRE*, *29:* 243–249, May 1941.

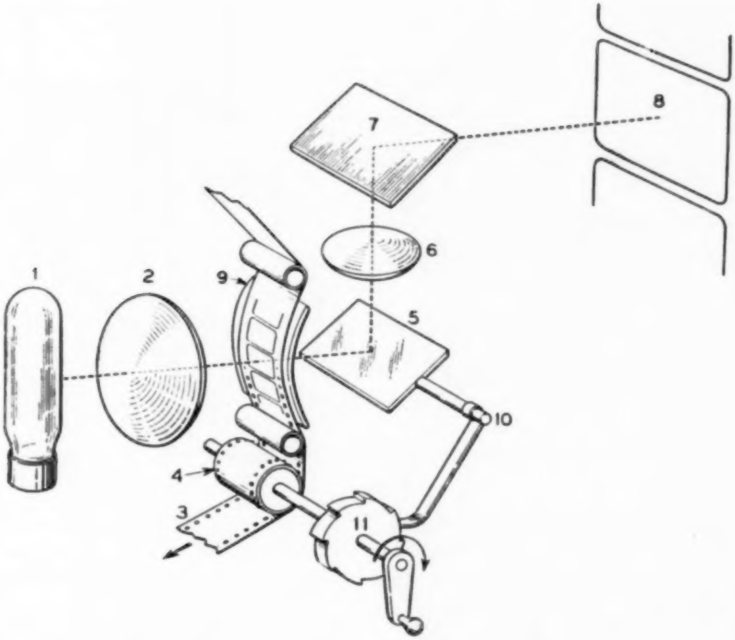


Fig. 1. Basic principle of operation of continuous projector.

of contrast, and the signals are still being used for test purposes in the laboratory. The chief shortcoming of this film scanner is the inconvenience and high cost of preparing the special 60-frame/sec film.

In order to obtain a wider range of picture material for test purposes, it was decided therefore to develop a continuous projector film scanner capable of using standard 24-frame/sec motion picture film. The design of such a scanner was made more feasible by the development of cathode-ray tube spot scanners with very short decay phosphors. Tubes of this type had been used with photomultipliers to produce television signals from still slides, and the resulting pictures showed very good resolution and a wide range of contrast.

In designing the optical system of this projector it was decided, as in the Mechau projector, to use a moving mirror system, since systems involving such mirror optics appear to have the best light efficiency, and freedom from certain refractive optics limitations. The design as evolved greatly simplifies the mechanical construction and operation by controlling all the mirrors from one simple stationary cam. During the development of the machine, further features were incorporated, such as an electrooptical servo system to eliminate picture jitter due to nonuniform film motion, and a second servo system to eliminate flicker due to nonuniform light efficiency through the frame cycle. The result is a laboratory model of a film scanner which is now being used for producing test signals and which is described in detail below.

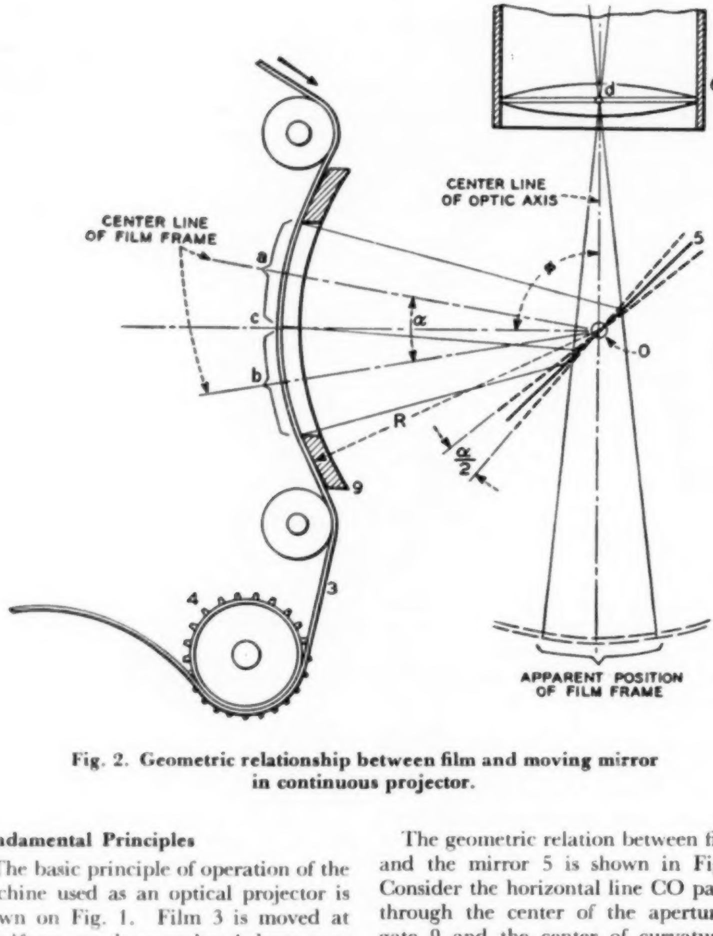


Fig. 2. Geometric relationship between film and moving mirror in continuous projector.

Fundamental Principles

The basic principle of operation of the machine used as an optical projector is shown on Fig. 1. Film 3 is moved at a uniform rate by sprocket 4 down over curved gate 9. Light from lamp 1 passing through condensing lens 2 and film 3 is reflected by compensating mirror 5 through objective lens 6 and reflected from fixed mirror 7 to screen 8. As sprocket 4 is rotated to move film 3, mirror 5 is caused to rotate about axis 10 by cam 11. The amount of rotation of mirror 5 is such that the image of the film on the screen produced by lens 6 remains stationary.

The geometric relation between film 3 and the mirror 5 is shown in Fig. 2. Consider the horizontal line CO passing through the center of the aperture in gate 9 and the center of curvature O of gate 9, as a fixed horizontal optical axis; also the radial lines aO and bO passing through the centers of two adjacent film frames a and b of film 3 and point O to form an angle α. Also consider line dO as a fixed optical axis passing through point O and the nodal point d of objective lens 6. Finally consider the reflecting surface 5 of a mirror pivoted about point O.

The requirement for optical compensation of the moving film is as follows:

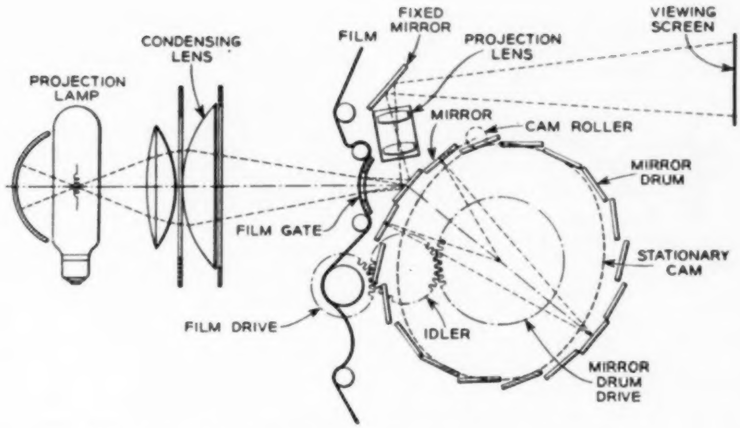


Fig. 3. Schematic diagram of mirror drum arrangement.

When a ray of light aO moves through the angle α to bO, the direction of the reflected ray Od must remain stationary.

This is accomplished by the rotation of mirror 5 about point O through an angle $\alpha/2$ while the film moves through the angle α.

Optically speaking, during the motion of the film through the gate, frame a appears stationary to lens 6, i.e., the apparent position of the film frame has not changed, as indicated on the figure.

The ratchet action suggested in Fig. 1 is obviously not suitable for any practical working mechanism. Therefore, for continuity of projection, the action of mirror 5 is made repetitive by using a suitable number of axially mounted mirrors equally spaced in a circle to form a sort of drum, the axes of the mirrors lying in the plane of the mirror reflecting surfaces and all parallel to the axis of the drum. As the drum rotates, the mirrors are then made to rotate at the required rate about their axes, by means of a suitable cam action. Figure 3 shows a schematic diagram of the mechanism. The mirror drum is geared directly to the film-drive sprocket, and as the drum rotates the individual mirrors are rotated through the required angle by means of cam followers rolling on a common stationary cam.

The continuity of the action of the mirrors is shown in Figs. 4a and 4b, where 4a shows one mirror at the middle of its compensation cycle and 4b shows two adjacent mirrors at the extremities of their compensating cycle. The axes e, h and j (perpendicular to the plane of the diagram) of the three mirrors shown are located on the arc of a circle with center of rotation at point d, the axis of the drum. Line Of is a diameter of the circle and lines de, dh and dj are radii to the mirror axes e, h and j. If the angles hde and hdj are both equal to β then the geometry of the system makes the angles efh and jfh both equal to $\beta/2$. Also lines drawn through e, h or j, perpendicular, respectively, to ef, hf and jf, will all pass through point O.

Referring to Fig. 2 it is seen that the angle α of the arc subtended by a film frame is equal to the angle β of the corresponding rotation of the mirror drum. It follows, therefore, that for proper compensation of film motion, the reflecting planes of the mirrors must at all times contain the respective per-

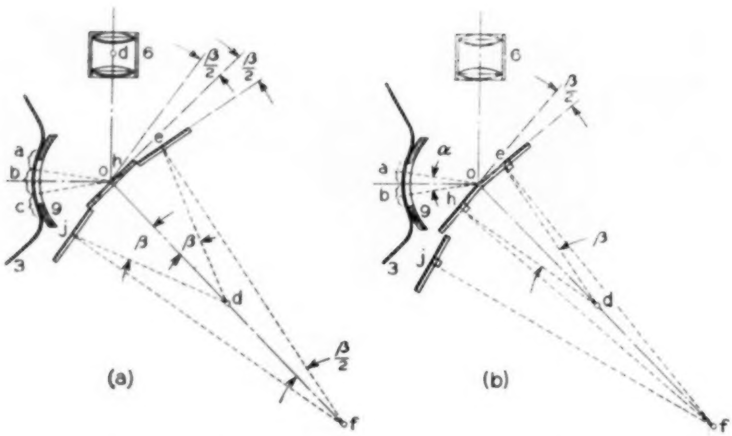


Fig. 4. Diagram illustrating proper motion of mirror through active compensation cycle. (a) One mirror at the middle of cycle; (b) two adjacent mirrors at overlapping part of cycle.

pendicular through e, h or j. In other words, during the active cycle the reflecting plane of a mirror must at all times contain the point O.

As the drum rotates and the mirrors obey the geometric principles just outlined, the reflected ray Od remains stationary while the film moves from a to b through angle α. Figure 4a shows the mirror in a position when frame b is at the center of the aperture in the gate, while Fig. 4b shows the mirror positions when the frame is at the limit of its travel in the gate.

Film Shrinkage

So far in this discussion, the consideration of the principles involved in the mechanism has been theoretical. It may be assumed that the mechanical parts can be made and assembled with the degree of accuracy necessary to satisfy the geometrical requirements for successful performance. On the other hand, the film is a plastic and therefore is mechanically unstable throughout its useful life. This instability must be considered in the design and suitable adjustment provided.

Standard 35mm motion picture film has a nominal frame pitch dimension of 0.748 in.; normal shrinkage, however, changes this value. In this projector design the longitudinal shrinkage requires consideration since its effect manifests itself at the curved gate by altering the angle subtended by a frame.

Referring to Fig. 2, it will be remembered that one picture frame (or really one frame pitch) in the curved gate should subtend an angle $\alpha = \beta$ for proper operation. As the film shrinks this angle α decreases and no longer corresponds to the associated mirror drum angular rotation of β, thus resulting in a frame-to-frame jitter of the projected picture. Exact compensation for shrinkage would require that the curvature of the film gate be increased, but for normal shrinkage it has been found adequate simply to move the gate a little closer to the mirror drum until a film frame again subtends the proper angle. Such an adjustment is provided for in the machine, together with a corresponding focusing adjustment of the projection lens.

Mechanical Specifications

So far the machine has been described in terms of a conventional optical projector and as such is shown in the schematic diagram of Fig. 3. In order to convert it into a film scanner all that is necessary is to replace the viewing screen in Fig. 3 by a cathode-ray spot scanning tube and to replace the projection lamp by a photomultiplier tube. As long as the projection lens is such as to provide the proper reduction from spot scanner raster size to film frame size, the remaining components of the machine are unchanged.

The geometric relations of these components are established by the choice of 18 compensating mirrors in the drum and an 8-frame drive sprocket as follows:

1. Angle α equal to frame pitch on the curved gate	20°
2. Angular separation β between adjacent mirror axes on the drum	20°
3. Radius R of curved gate	2.142 in.
4. Angle of rotation of the mirrors about their axes while traversing the active arc	10°
5. Rotational speed of drum	80 rpm
6. Number of mirrors in drum	18
7. Number of teeth on drive sprocket	32
8. Number of frames per revolution of drive sprocket	8

Constructional Details

Film drive. The drive is of more or less conventional design incorporating the usual feed sprockets, idlers and drive sprocket. A friction-controlled film-tensioning sprocket immediately above the gate serves to keep the film taut during its passage through the gate, in order to insure proper radius of curvature while it is being scanned.

Mirror assembly. The outer diameter of the mirror drum is about 14 in. and it has 18 equally spaced mirror units mounted along the periphery on a diameter of 11½ in. The general arrangement may be seen from the photographs in Fig. 5 and Fig. 6.

An individual mirror unit as shown in Fig. 7 consists of bearing housing 1, mirror support casting 2, shaft 3, mirror 4, bearings 5, bearing spacer 6, lock nut 7, mounting screws 8 and mirror setscrews 9.

The bearing housing is accurately machined to fit the holes in the drum. In order to maintain the necessary locational accuracy and allow easy assembly, the finished bearing cylinders are etched except for four contact areas as shown in Fig. 7. These areas are located about the threaded clamp screw hole, and when in place are the only surfaces that are in contact with the drum bore.

The shaft 3 is mounted in the shell on two ball bearings, preloaded by the proper adjustment of the spacer 6 to eliminate any radial motion. The mirror support casting 2 is mounted on the flange of the shaft. The contact face of the flange is machined after assembly in the shell to insure an accurate alignment of the casting 2. The corresponding face of the casting 2 is also machined on a special fixture to insure an accurate 90° angle between the mirror face and the flange face.

The casting 2 is designed with machined pads with steel ball inserts, which support and locate the mirror at the reflecting surface, the mirrors being of the front-surface type.

The mirrors are made of glass 2 × 3 × ¼ in. thick, and the surface is flat to one wavelength in visible light.

Cam Follower. The cam follower and adjusting detail are mounted on the cylindrical end of the flanged mirror shaft as shown on Fig. 7. This mechanism consists of roller 10, roller shaft and nut 11, follower casting 12, shaft adjusting casting 13, tension

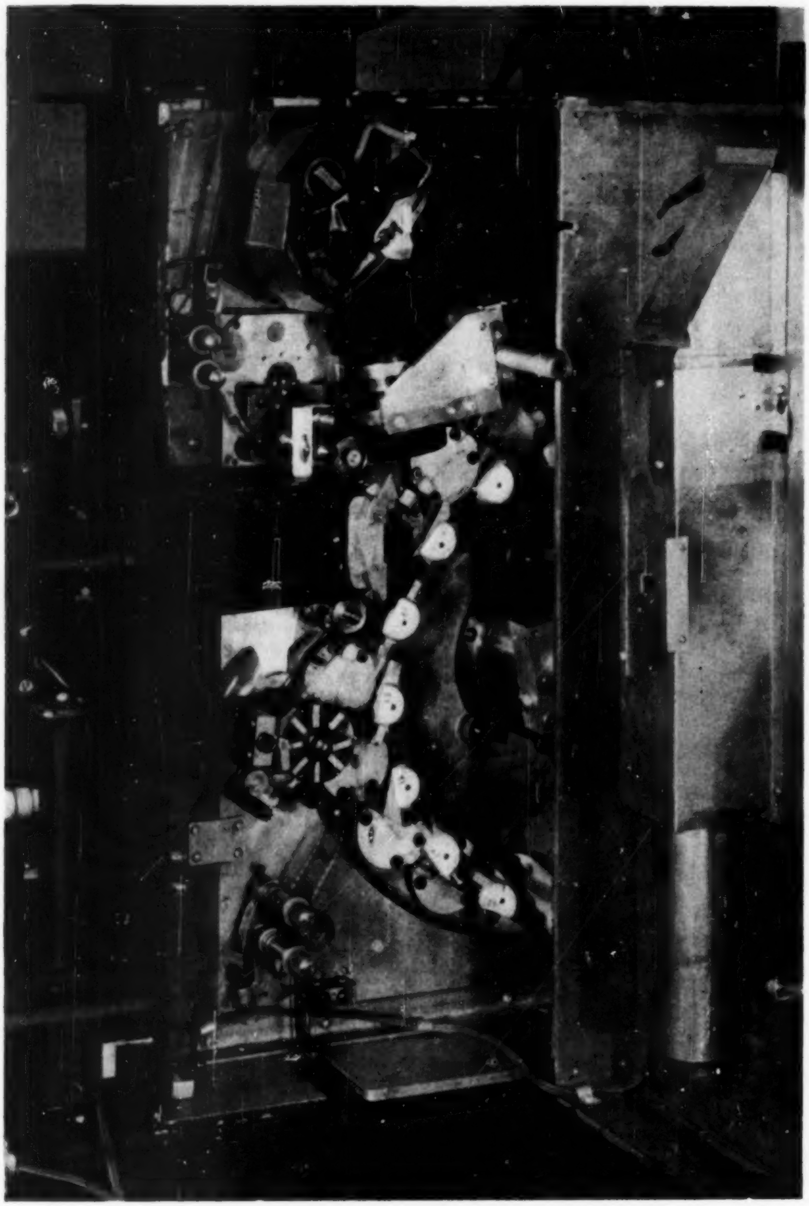


Fig. 5. Photograph of mechanism showing moving mirror drum.

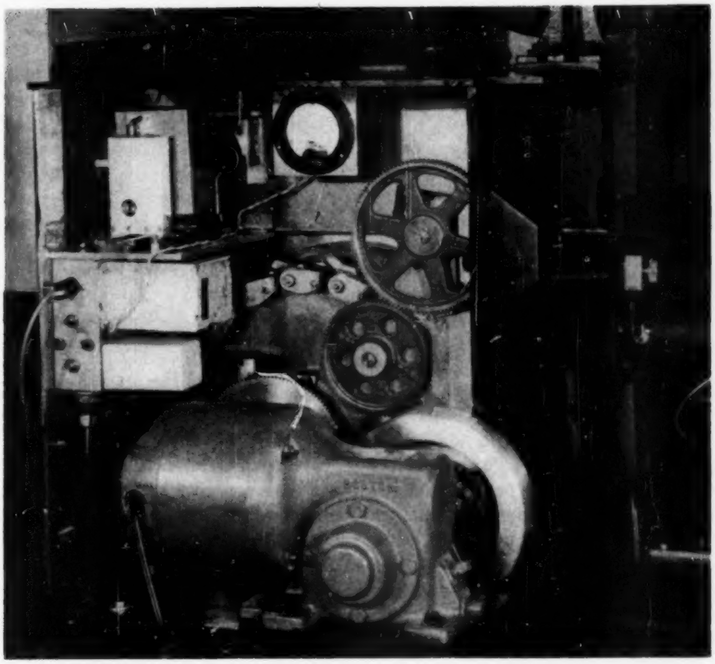


Fig. 6. Photograph of mechanism showing stationary cam and cam followers.

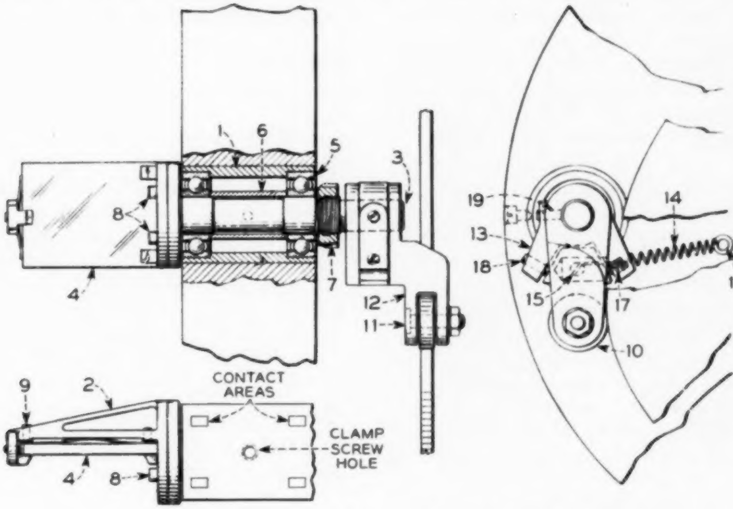


Fig. 7. Mechanical details of drum mirror assembly.

spring 14, spring pin 15, spring stud 16, adjusting pressure spring 17, adjusting screw 18, and setscrew 19.

Spring 14 maintains contact of roller 10 on the cam. Stud 16, to which one end of spring 14 is fastened, is fixed to the body of the drum; the other end of the spring is anchored to the roller casting by pin 15. Spring 17 maintains loading on the adjusting screw 18, which, when turned, changes the angular setting between the follower casting 12 and the mirror shaft 3, thereby allowing the relative mirror angle to be changed.

A photograph of a mirror unit and cam follower is shown in Fig. 8.

Cam. The design of the stationary cam was considered from two requirements: (a) the optical performance of the mirrors and (b) the dynamic balance of the drum. For the optical performance a 40° segment of the cam is all that is necessary. It is this segment that produces the compensation; the remainder is used simply to return the cam follower roller to the beginning of the segment. Dynamically, however, in order to eliminate any unbalance in the rotating system (drum), duplicate cam segments must be located diametrically opposite each other. In this manner the radial distance of opposite mirror mounting castings and associated cam follower mechanisms will always be the same and thereby provide the necessary counterbalance. The final shape of the cam is indicated in Fig. 3 and a portion of the cam may be seen in Fig. 6. A feature of the cam curve is that it can be generated quite easily with a grinding fixture constructed for the purpose. A schematic diagram of the fixture is shown in Fig. 9. In this figure point B represents the axis of rotation of the mirror drum and the circle D represents the location of the axes of rotation of the individual mirrors. Point A corresponds to the point O in Figs. 2 and 4, and point C corresponds to point f in Fig. 4. The fixture consists of two movable arms 1 and 2, interlinked at point E. Arm 1 rotates about point B and arm 2 rotates and slides about point C. The grinder is fixed on arm 2 in such a manner that the center of the grinding wheel is located at point F, where the distance EF is equal to the center-to-center length of the cam follower arm. The diameter of the grinding wheel is equal to the diameter of the cam roller. A photograph of the grinding fixture is shown in Fig. 10.

Position Control

The fundamental principles of operation of this machine were discussed on page 5. If these are fulfilled, if the gears are perfect, without backlash and with correct teeth profile, if the cam has the correct shape and the cam followers are correctly aligned, and above all, if the friction is constant so the film moves at an absolutely uniform rate, then the images on the screen of succeeding film frames will fall exactly on top of each other. The image of each frame will lap dissolve into the image of the previous one without blurring and without loss of registration. In other words, the picture on the screen will be steady without any vertical jitter. Conversely, if the machine is used for film scanning, the image of the scanning raster on the film surface will move in such a manner as to remain stationary with respect to the film frames and no vertical motion or jitter will be observed in the resulting picture on a television receiving tube.*

The present machine does not perform in this perfect manner. It is assumed that the friction in the film drive is not constant, but whatever the cause, the fact is that without any further control, the image moves up and down erratically with a maximum excursion of

*The discussion above relates only to vertical motion of the image. It is assumed that adequate guides in the film drive prevent any sideways weave of the image.

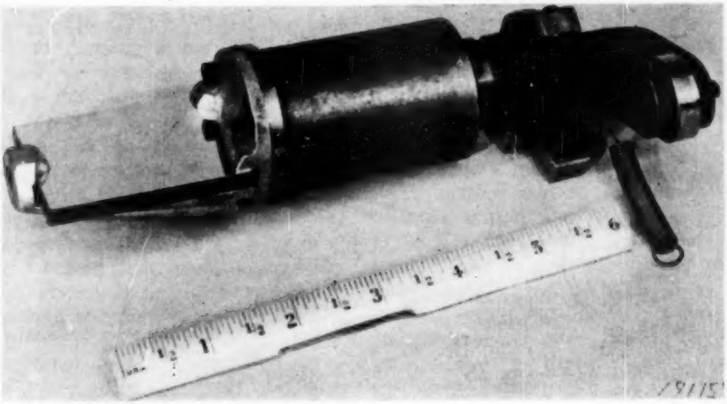


Fig. 8. Photograph of drum mirror assembly.

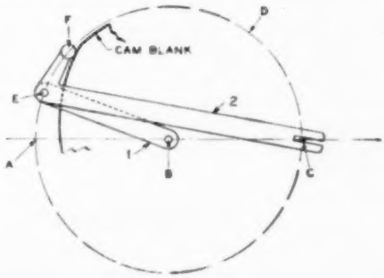
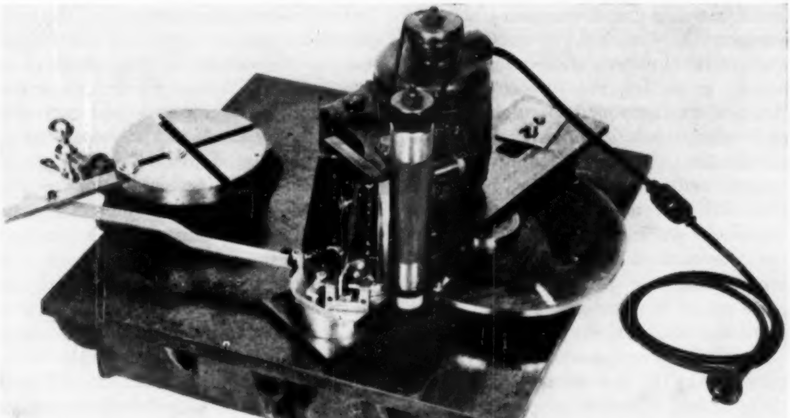


Fig. 9. Diagram of cam grinding jig.

Fig. 10. Photograph of cam grinding jig.



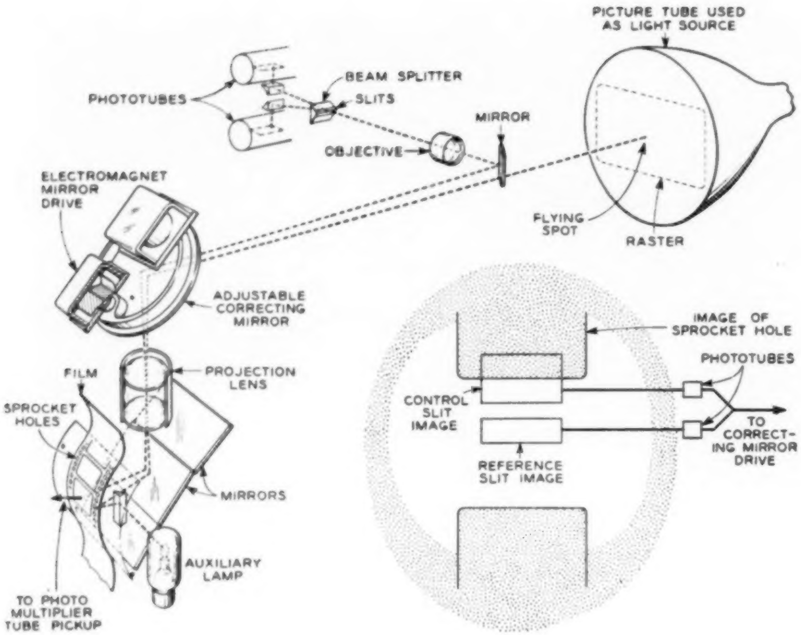


Fig. 11. Schematic diagram of jitter correcting servo system.

about 1/100 of the picture height. This is, of course, disturbing, and would be intolerable in a commercial film scanner. It was decided, therefore, to attempt to eliminate this vertical jitter, not by perfecting the mechanical precision of the component parts, since such perfection would probably require a continuous, time-consuming maintenance effort, but rather by automatically monitoring the departure from uniformity in film motion, and using the indications of such departures to control some element of the system in such a way as to counteract or nullify the vertical jitter.

In the entire processing of motion picture film from camera to projector, the primary standard of registration is the location of the sprocket holes in the film. It is natural, therefore, to use these sprocket holes as a means for measuring the departure from proper motion of the film. Assuming that such "error" information is available, the next question is where to apply it to compensate for the error. In Fig. 3 there is shown a fixed mirror for deflecting the light from the projection lens onto the viewing screen. If this mirror is made adjustable around an axis in the plane of the mirror and perpendicular to the plane of the diagram, then such an adjustment would impart a vertical motion to the image on the screen. In other words, if the "error" signal obtained from monitoring the sprocket-hole position is used to tilt the mirror in such a way as to counteract the error, then the image on the screen will stay still in spite of nonuniform film motion. This is exactly what is done by the jitter-correcting control circuit, or servo, incorporated in the machine, and the

method employed is shown by the schematic diagram in Fig. 11.

This figure shows the essential features of the mechanism used as a film scanner. The light from the raster of the spot scanning tube is transmitted via the correcting mirror through the projection lens, and via the drum mirror through the film onto the cathode of a photomultiplier tube.

An auxiliary light path through the optical system is provided as follows: The sprocket-hole area of the film is illuminated by light from a small incandescent lamp passing through a right-angle prism mounted adjacent to the film gate (see Fig. 11). As far as this sprocket-hole area is concerned the machine now functions as an optical projector. The reflected light from the film surface is passed back through the system as indicated in Fig. 11 and an image of the sprocket-hole area is formed in a vertical plane marked "slits" in the figure. A picture of this image is shown as an insert in Fig. 11. The sprocket holes themselves will appear black in this image, while the film area around the sprocket holes will show uniform illumination.

In this image plane there is placed an opaque mask with two narrow slits as shown in the insert. The lower slit covers part of the film image between two sprocket holes and is used as a reference source, while the upper slit partly overlaps the image of the sprocket-hole edge and is used as a control source. By means of prisms the light from the two slits is passed to two separate photomultiplier tubes and the electrical output from these is passed through a differential amplifier to two electromagnets controlling the position of the correcting mirror.

The system is so adjusted that for the reference position of the image as shown in the diagram the output of the two phototubes is the same. The differential amplifier, therefore, passes no current to the electromagnets and the correcting mirror stays fixed. If, on the other hand, a sudden perturbation in the film motion causes the sprocket hole image to move upwards, then the output of the phototube corresponding to the upper slit will increase. The differential amplifier will then pass a corresponding current to the electromagnets and tilt the correcting mirror in such a direction as to restore the sprocket-hole image and thus the main image to its original position.

It is seen that this electrooptical control system is indeed a servo or feedback system, in that it automatically will tend to keep the "error" signal small at all times. The gain of the electrical part of the system must be high enough to keep residual errors down to a negligible amount, and the frequency bandwidth of the system must be sufficient to make the reaction time short compared to the frequencies of normal perturbations of film motion. In the present system the loop gain is about 50 db at low frequencies and gradually decreases to zero gain at about 250 cycle/sec. A measure of the performance of the system may be had by introducing a sudden electrical disturbance into the circuit. With such a disturbance introduced, the correcting mirror will readjust itself in approximately one millisecond, without any appreciable overshoot.

The mechanical construction of the correcting mirror is shown in Fig. 12. The glass mirror 1 is about $3 \times 4\frac{1}{2}$ in., fashioned from a plano-convex lens with the plane surface polished flat to about one wavelength of visible light. The mirror is cemented to an aluminum frame 2, which in turn is spring supported to the fixed frame 3. The supporting springs are clamped in the fixtures 4. The springs are 0.005 in. thick, 0.03 in. wide and 0.005 in. long between clamping points. The driving electromagnets are shown at 5. The peak-to-peak deflection of the correcting mirror during normal operation is of

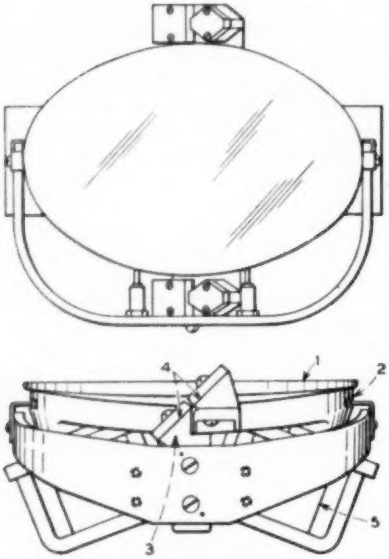


Fig. 12. Mechanical construction of jitter-correcting mirror.

the order of 5 to 10 minutes of arc, and the peak power required to drive the mirror is less than one watt.

The sprocket-hole edge used for control is the trailing edge in the passage through the film drive, since this edge is not subject to gradual deterioration due to drive-sprocket pressure.

It may be asked why the servo system uses light reflected from the film surface, rather than light transmitted through the film. The answer is that the reflection coefficient of the film surface is practically independent of the transparency of the film. If transmitted light were used the control light would be affected by the degree of exposure of the emulsion around the sprocket holes, by surface scratches in the film and, above all, by the fact that some film manufacturers print their firm name at frequent intervals along this part of the film.

In this discussion of the position servo system only nonuniformity of film motion has been mentioned as a source of vertical jitter. Other sources of jitter may be present, such as gear teeth irregularities, cam motion irregularities, optical misalignment, etc. Since the servo system in effect controls the position of the final image, it will tend to minimize vertical jitter due to any of these causes. Even film shrinkage is to some extent compensated for automatically by the servo.

Control of Illumination

As one mirror on the drum approaches the end of its active cycle the light from this mirror will gradually decrease, while the light from the succeeding mirror increases. In an ideal system these opposite changes in light transmission should exactly cancel each other, resulting in constant overall light efficiency throughout the cycle. In the actual machine this is not quite so. An analytical study involving ray tracing through the cycle indicates that for the period when two mirrors are contributing light to the screen there is a small amount of masking of the light falling on one mirror by the edge of the previous mirror. Also during this part of the cycle the projection lens is not entirely filled by light from the two mirrors together.*

The result of this analysis is shown in Fig. 13. It is seen that for about three-quarters (15 degrees) of the active cycle, one mirror, and therefore one film frame, contributes more than 80% to the illumination on the screen. For the remainder of the cycle two adjacent mirrors contribute to the illumination. It is seen that for a small part of this overlapping period the contribution from one mirror (No. 2) falls off faster than the contribution from the next mirror (No. 3) increases. The result

* This study was made on the assumption that the machine was used for optical projections with uniform illumination of the film gate. It is, of course, equally valid when the machine is used as film scanner with a cathode-tube raster of uniform illumination.

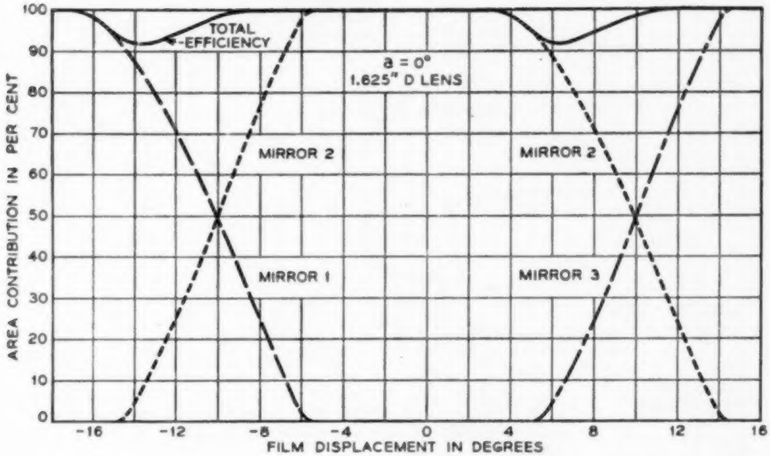


Fig. 13. Variation of light efficiency through mirror compensating cycle.

is a decrease in overall illumination of about 10%, lasting for a small fraction of the active cycle.

The result of this light variation is a certain amount of flicker, scarcely noticeable in the projected image in case of optical projection, but more objectionable in the television image in case of film scanning. In the latter case, low-frequency beats are formed between the 24-cycle film frequency and the 30-cycle television frequency. These low-frequency variations are more disturbing than the small amount of 24-cycle variation present in optical projection. The variation is clearly noticeable when the machine is turned slowly by hand. It manifests itself as a slightly darker horizontal band traveling down the picture as one picture frame fades out and the next fades in.

The analytical study mentioned above indicated that the light variation might be decreased in either of two ways. The edges of the projection lens might be masked off, resulting in lower overall light efficiency, or the number of mirrors on the drum might be increased, resulting in a larger mechanical structure. Since neither method would entirely eliminate the light variation it was decided instead to incorporate in the machine a light-controlling servo system which would compensate for all such cyclic variations in light efficiency.

The principle of this light-servo system is shown in the diagram of Fig. 14, which again shows the principal parts of the machine used as a film scanner. The main light path is from the cathode-ray tube raster through the optical system, through the film in the gate and into the signal photomultiplier. By means of a plane mirror mounted next to the raster an auxiliary light path is provided which also sends light through the optical system, but this light passes through a clear gate at the side of the film gate and from there to an auxiliary photomultiplier. The output from this phototube is then properly biased and impressed on the intensity-control grid of the scanning tube. As long as the light efficiency of the optical system is constant the auxiliary phototube output is constant and is so biased that no control voltage is impressed on the intensity-control grid of the cathode-

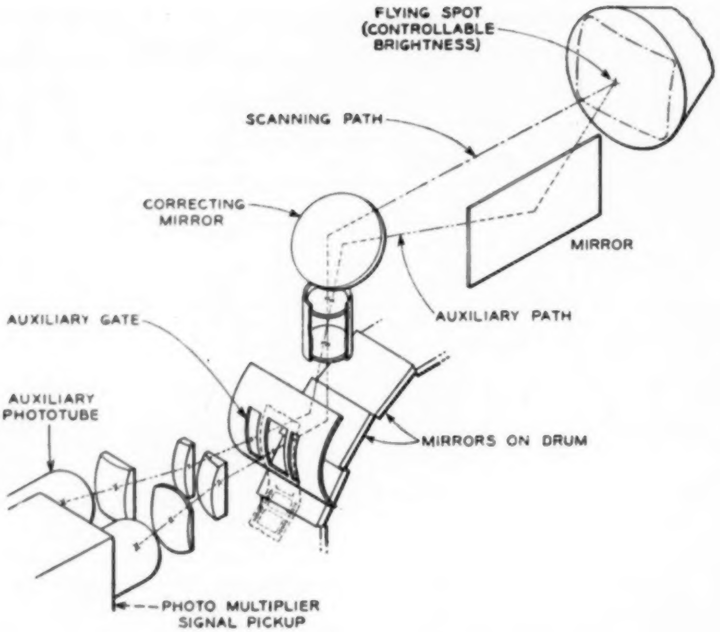


Fig. 14. Simplified schematic diagram of flicker-correcting servo system using separate phototube.

ray tube scanner. If the light efficiency changes, then the corresponding change in phototube output voltage is impressed on the scanning tube grid in such a manner as to restore the illumination of the gate to its original value. Like the position-control system discussed earlier, this light-control system is also a servo or feedback system, which automatically will tend to keep the illumination at the gate constant. The gain and the bandwidth of the electrical part of the system are such that residual light variations are kept to a negligible minimum and that the reaction time of the servo system is fast compared to the periodicity of the light fluctuations in the optical system.

As shown in Fig. 14 the system has the disadvantage of using two photomultipliers, one for the television signal and one for the light-control signal. This requires that any nonuniformities in the photosensitivities over the cathode areas used must be absolutely identical in the two tubes since the illuminated areas on the photocathodes are not the same throughout the cycle. If the variations in cathode sensitivity are different, this will result in a false indication of light efficiency and will actually cause flicker. To avoid this difficulty a modified system was adopted as shown by the diagram in Fig. 15.

In this diagram the drum mirrors and the position-correcting mirror have been left out for the sake of simplicity. Figure 15a shows the spot scanning tube, the projection lens, the film gate and adjacent clear gate or monitoring slit, and finally the common condenser lens and photomultiplier. Figure 15b

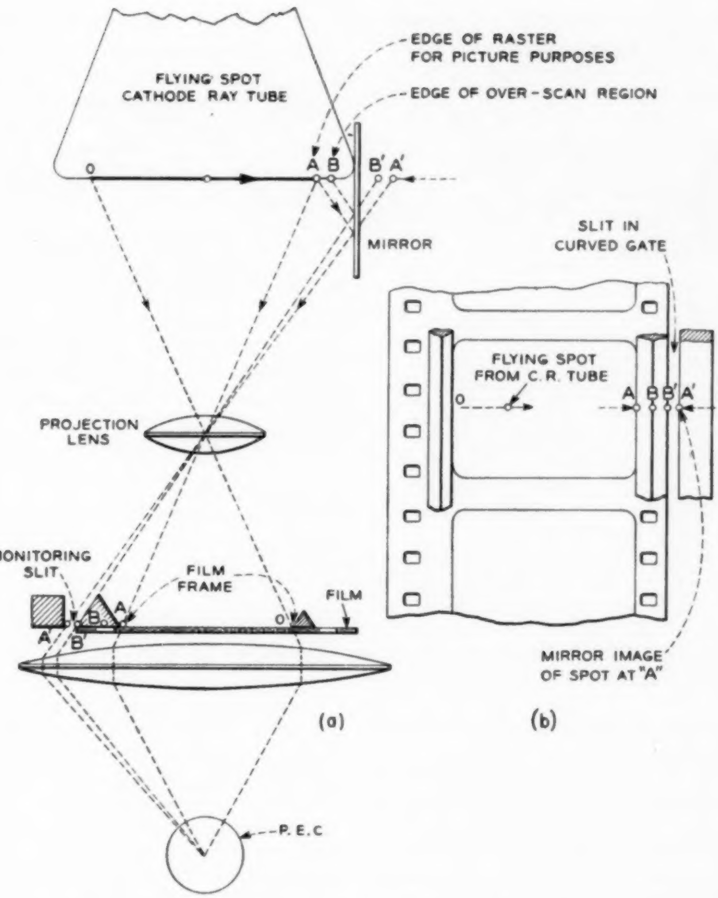


Fig. 15. Schematic diagram of pulse-operated flicker-correcting servo system using signal phototube.

shows a view of the film gate and monitoring slit. As the scanning spot travels horizontally across the tube face from O to A, the image of the spot travels across the film from O to A, the light through the film thus producing the usual television line signal at the output of the phototube. At A the light is cut off by the edge of the film gate. The spot on the tube, however, is allowed to travel a little further until it is blanked off electrically at B. This part of the travel, from A to B, is reflected through the system by a plane mirror in such a manner that the corresponding image travels across the monitoring slit from A′ to B′. The light through the slit passes to the phototube and produces a short pulse immediately following the line signal, the

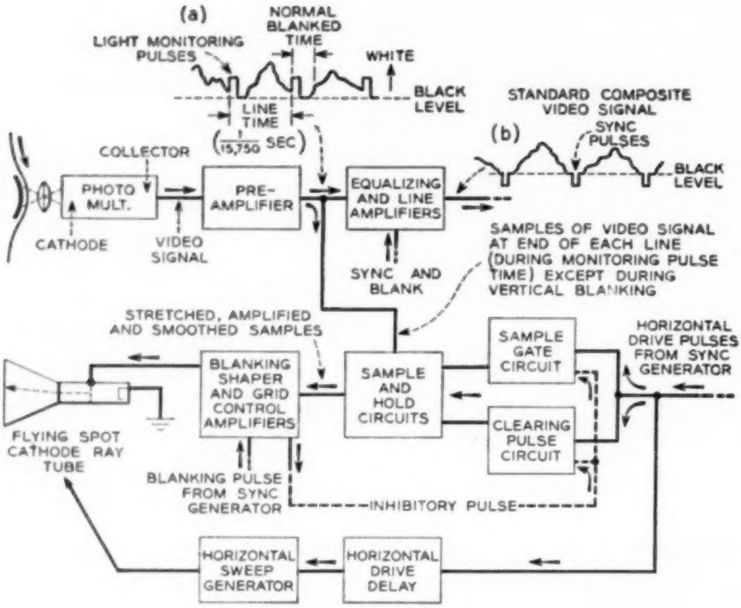


Fig. 16. Block diagram of electrical circuits in flicker servo system.

amplitude of this pulse being a measure of the light intensity in the gate.

The further processing of the photomultiplier signal is shown by the block diagram in Fig. 16. After preamplification the signal appears as shown at a, consisting of a normal line video signal, followed by a short pulse of amplitude proportional to light intensity in the gate. The preamplifier is followed by an equalizing amplifier and a line amplifier, where the light monitoring pulse is blanked out and replaced by standard synchronizing signals supplied by the studio sync generator. The output of the line amplifier is shown at b and consists of a standard composite video signal, ready for transmission.

From the preamplifier the signal also passes to a box marked "sample and hold." In this box the amplitude of the light monitoring pulse is sampled by means of a sample gate circuit and then the sample is "stretched" in time by a holding circuit until it occupies almost the entire time interval until the arrival of the next sample one line later. After some filtering the output of the "hold" box therefore consists of a quasi d-c voltage which is constant in amplitude as long as the gate illumination is unchanged. This d-c voltage is then fed to the grid-control amplifier, which in turn controls the light intensity of the scanning spot. If the gate illumination changes, the monitoring pulse amplitude changes accordingly, thereby changing the d-c holding voltage and the spot intensity in such a manner as to bring the gate illumination back to its original value. Before the control voltage is applied to the cathode-ray tube grid, blanking pulses are inserted to blank off the beam at B in Fig. 15.

Optical Components

The machine is presently designed for scanning black-and-white film. It is possible, therefore, to use on the spot scanning tube a phosphor with the shortest possible decay time, namely, the P16 phosphor, which gives peak light response in the near ultraviolet region. The spot scanner is of conventional design and uses an RCA 5ZP16 tube with an anode voltage of 30 kv. The signal photomultiplier is an RCA 5819 tube with an S_4 photo surface, which is sensitive in the ultraviolet region. The overall spectral response of spot scanner and photomultiplier stretches from about 3500 to 4000 A, with peak response at about 3750 A.

At these short wavelengths it is necessary to pay attention to the transmission losses in the image-forming components, i.e., the condenser lens and the projection lens. The condenser lens is made of quartz and may be assumed, therefore, to have very small transmission loss in the wavelength region used. The projection lens is a modified Kodak Ektar projection lens, 100mm focal length, $f/3.5$. It has been redesigned for the present purpose to work at a magnification of 4:1 and to have best chromatic performance in the region around 3750 A. The glass of the lens measures about 75% transmission at this wavelength. Assuming 10% reflection loss at each mirror surface, we thus have an overall transmission efficiency of $0.9 \times 0.9 \times 0.75 = 0.60$. The lens is stopped down to about $f/4$ and the overall effective speed of the system is thus about $f/5$.

The lamp used for the position control is a 100-w, 110-v tungsten lamp operated at about 60 v and the photomultipliers used for this control are RCA 931A tubes.

Overall Performance

The geometrical resolution obtainable with the machine at present is such as to resolve clearly the bottom of the vertical wedge on the standard RTMA test chart. On pictures of the same RTMA chart all ten strips in the gradation wedges can be clearly distinguished on the face of the monitoring tube. On a 10-in. kinescope contrast ranges over 200 to 1 have been measured from pictorial scenes of the standard SMPTE test film, with adequate gradation in the halftones.

The residual vertical jitter of the picture has an rms value of about 1/2000 of the picture height, or about 1/4 of a scanning-line pitch. The sideways weave of the picture is larger than that, due to the fact that the film is not guided as well as might be desired. It is felt that this weave can be reduced by proper mechanical guiding, but if still better performance is desired, it should be comparatively easy to monitor the edge of the film with a photocell arrangement, and to impart this monitoring signal to a second pair of electromagnets on the correcting mirror.

The signal-to-noise ratio of the video signal from the machine is about 35–40 db, peak signal to rms noise. Undoubtedly this figure can be improved by using a faster lens, maybe an $f/3$ or even an $f/2$ lens. It should be mentioned, however, that a faster lens will have less depth of focus and will be unable to focus the flat tube raster sharply over the curved film frame. With the present lens there is no serious lack of sharpness at the upper and lower edge of the picture. With a much faster lens it would probably be necessary to provide a field-flattening lens to compensate for the film curvature.

Bibliography

1920

C. F. Jenkins, "Continuous motion picture machines," *Trans. SMPE, no. 10:* 97–102, May 1920.

1921

C. F. Jenkins, "Continuous motion pro-

jector for the taking of pictures at high speed," *Trans. SMPE, no. 12:* 126–127, May 1921.

1922

C. F. Jenkins, "Prismatic rings," *Trans. SMPE, no. 14:* 65–71, May 1922; discussion, *ibid.*, 72–73.

F. N. Stewart, "Note on new continuous projector," *Trans. SMPE, no. 14:* 162, May 1922.

1923

H. D. Taylor, "The feasibility of cinema projection from a continuously moving film," *Trans. Opt. Soc., no. 25:* 149–176, May 1923–1924.

1924

L. Bowen and H. Griffin, "Is the continuous projector commercially practical?," *Trans. SMPE, no. 18:* 147–151, May 1924.

1928

A. J. Holman, "A non-intermittent optical projector," *Trans. SMPE, vol. 12, no. 36:* 1184–1188, Sept. 1928; discussion, *ibid.*, 1188–1190.

J. F. Leventhal, "A new optical compensator," *Trans. SMPE, vol. 12, no. 36:* 1068–1072, Sept. 1928; discussion, *ibid.*, pp. 1072–1075.

J. F. Leventhal, "Projectors with optical intermittents," *Trans. SMPE, vol. 12, no. 34:* 406–409, Apr. 1928.

"The Mechau projector," *Trans. SMPE, vol. 12, no. 36:* 1193–1195, Sept. 1928.

1930

A. J. Holman, "Apparatus developed to simplify manufacture of lens wheels for continuous projectors," *Jour. SMPE, 14:* 623–635, June 1930.

A. J. Holman, "Prospects for non-intermittent projection," *Mot. Pict. Projectionist, 3:* 9–10, Oct. 1930.

A. J. Holman, "The revolving lens wheel projector," *Jour. SMPE, 15:* 20–38, July 1930.

A. J. Holman, "Why and how of continuous projection," *Mot. Pict. Projectionist, 4:* 25–26, 31, 33–37, Nov. 1930.

F. H. Richardson, "Continuous projection: an inquiry," *Exhibitors Herald-World, 100:* 49–50, July 5, 1930.

1931

A. J. Holman, "Continuous non-intermittent projectors," *Jour. SMPE, 16:* 612–618, May 1931.

M. Huc, "Non-intermittent motion picture projector," *Bull. Soc. Franc. Phot., 18:* 128–136, June 1931. Abstract in *Eastman Monthly Bull., 18:* 17, Jan. 1932.

Carlos Mendizabel Brunet, "New continuous projector shown by inventor," *Mot. Pict. Herald, 103:* sec. 1, 19, May 16, 1931.

"New non-intermittent projector," *Kinemat. Weekly, 174:* 55, Aug. 20, 1931. Abstract in *Eastman Monthly Bull., 18:* 134, Mar. 1932.

W. C. Plank, "Art of continuous cinematography," *Internat. Proj., 1:* 22–23, Nov. 1931; *ibid.*, pp. 9–11, Dec. 1931.

W. C. Plank, "Some interesting properties of continuous projectors," *Jour. SMPE, 16:* 709–718, June 1931.

1932

A. Bourgain, "Non-intermittent projectors," *Technique Cinemat., 13:* 69–76, Feb. 1932. Abstract in *Eastman Monthly Bull., 18:* 337, July 1932.

Plank, W. C., "Inertia in the service of cinematography," *Jour. SMPE, 19:* 565–578, Dec. 1932.

"A portable non-intermittent cine projector," *Jour. SMPE, 18:* 101–106, Jan. 1932.

H. A. Robizek, "Continuous projection by optical compensation," *Internat. Proj., 2:* 14–16, Mar. 1932.

J. L. Spence, "Mechanical advantages of the optical intermittent projector," *Jour. SMPE, 18:* 593–599, May 1932.

F. Tuttle and C. D. Reid, "The problem of motion picture projection from continuously moving film," *J. Opt. Soc. Am., 22:* 39–64, Feb. 1932; Bibliography, *Jour. SMPE, 20:* 3–30, Jan. 1933.

1933

"A new continuous projection attachment just announced by Victor," *Am. Cinematographer, 13:* 20, Mar. 1933.

M. Pirani and R. Rompe, "Uber Kinoprojektion mit kontinuierlick abrollendem Film," (on the projection of continuous film), *Kinotechnik, 15:* 131–132, Apr. 20, 1933.

F. Tuttle, "A non-intermittent high-speed

16-mm camera," *Jour. SMPE, 21:* 474–477, Dec. 1933.

1934

R. H. Cricks, "The non-intermittent: some attempts at continuous projection," *Ideal Kinema, 2:* 40–43, Sept. 13, 1934. Abstract in *Eastman Monthly Bull., 21:* 161, May 1935.

1937

Fernseh-Filmabtastgerät, "Television film scanning device," *Mechau Filmtechnik, 13:* 163–164, Oct. 1937.

1938

H. S. Bamford, "Non-intermittent projector for television film transmission," *Jour. SMPE, 31:* 453–461, Nov. 1938.

1940

F. Ehrenhaft and F. G. Back, "Non-intermittent motion picture projector," *Jour. SMPE, 34:* 223–230, Feb. 1940.

1944

R. H. Cricks, "The requirements of modern projector design," Bibliography, *Jour. SMPE, 43:* 129–147, Aug. 1944; discussion, *ibid.*, 147–148.

Discussion

Anon: I am sure we all agree that you have done a wonderful job . . . . I'm wondering if you feel that you have sold yourself down the river at all in utilizing the sprocket hole instead of trying to use the frameline on the film in some way?

A. G. Jensen: We felt that the sprocket hole, as far as we understand it, is the primary standard that you have in the motion picture. The whole registration all through the processing is done by means of these sprocket holes, so we felt that they were the primary standard and we were afraid we couldn't hope to do much better than that. If you go by the frame then you are in trouble, because depending upon the film material you don't always have a good reference. You might have to make an artificial reference in order to make sure that you always have a good reference edge — a nice black-to-white edge which will not vary with the content of the picture. When you go by the sprocket hole you don't have that at all. Another thing — it is very difficult, I think, to do a good job of monitoring if you use transmitted light. If you were to use a film frame you would almost be forced to use transmitted light and depend upon black vs. clear film, as I see it. By using the sprocket hole we use reflected light and that seems to be practically independent of what has happened to the film as far as exposure is concerned. Whether the area around the sprocket hole is clear film or completely black exposed film doesn't matter at all. The reflected light is almost independent of that, which is a great advantage. If you were using transmitted light the gain of your servo, the dependability of your servo would depend on the density of the film at the point where you measure. We have avoided that by using reflected light.

Anon: Are you of the opinion that you could use old film and new film and the results would be about the same? The trouble with a lot of television operations is that the prints aren't always good.

Mr. Jensen: Of course I might say that the edge of the sprocket hole that we monitor on is a trailing edge, the one that is least chewed up by sprockets.

John Kudar: Mr. Jensen, a few months ago, I think in *Electronics*, there was an article about this projector and there was a remark that the jitter control would be able to compensate for shrinkage.

Mr. Jensen: Well, it is true that if the shrinkage is not too bad it does do a fairly good job of compensating. If the shrinkage is severe then you do have to adjust the gate, but it isn't too complicated to do. The shrinkage would generally be uniform enough through an entire piece of film so that you don't have to adjust while you're running, but if the film is badly shrunk you may have to adjust initially before you start that piece of film by moving the gate a little bit closer or a little bit further away from the mirrors.

Color Television Reproducers

By HARRY R. LUBCKE

Altering the velocity of traverse of the electron stream in combination with a suitable heterogeneous reproducing screen is the basis of a device described. It differs from the CBS mechanical, the RCA tricolor tube and the Geer screen systems of color television reproducers.

ACHIEVING the right combination of elements for the reproduction of color television is not easy. By counting the issued patents concerned with this problem and observing the accelerated rate at which these are issuing we must conclude that many are now engaged in such research—from the individual inventor to the lush corporate laboratory working around the clock.

One of Zworykin's original patents[1] on the iconoscope, filed in 1925 and now expired, disclosed the elemental type of color screen that is being reinvented to the present day. Another example is due to Bronwell[2] of Chicago. Three grids are provided for a three-color system, arranged in lieu of the fluorescent screen. The wires of one screen are staggered with respect to the wires of the others as regards electron flow. By the expedient of raising the voltage on the grid that carries the color phosphor to be energized at a given instant, the electrons are attracted to it in preference to the other grids and impinge upon it with sufficient velocity to fluoresce the phosphor on that grid alone.

The first all-electronic color television reproducer to be produced in any quantity is the well-known tricolor tube of the Radio Corporation of America. This tube is an improvement of the original obturating principle of the German corporation "Fernseh Aktiengesellschaft" (translated: "Television Corporation") proposed in their French Patent No. 866,065, filed in July 1939.

Fernseh showed rods disposed in only one direction, like pickets on a fence. These were in front of a lined triphosphor screen. RCA did one better than this, by stamping a plate full of holes and arranging three dots of different phosphors behind each hole on the side near the viewer.

Still another scheme is the Geer screen.[3] This was a fundamental invention. It reproduces a color image upon a substantially single plane while retaining necessary uniqueness of rendition of the color components that form the image.

The practical importance of the single-color image has become apparent as the art has progressed. The science of

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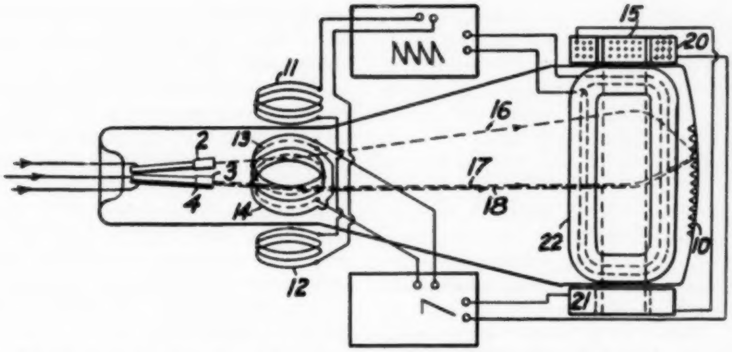

Fig. 1. A three-gun faceted-screen color television reproducing device. The divergently formed electron streams are converged at the screen by the coil assembly.

optics has taught long enough how to combine three-color component images into the full-color composite, but it is inadvisable to leave the matter of registration to the cabinetmaker and the serviceman if there is a better way. The Geer screen allows combination of the colors in proper registration without complicating the electron optics of the device *at the screen proper.*

The tube of Geer and of his contemporaries, A. N. Goldsmith[4] and the late John Logie Baird[5] of England, suffers from the need for (usually) double keystone correction. This is occasioned because of the considerable physical separation of the three electron guns of the devices. If there was a way in which this separation could be eliminated a great improvement would result.

The author evolved an answer to this[6] in the form of a cluster of three guns that originate mutually divergent electron streams at essentially one point. This arrangement is shown in Fig. 1 as guns 2, 3 and 4. The electron streams from these are deflected as a whole by a single set of deflection coils—11, 12, 13 and 14. This arrangement has the advantage of simplicity and accuracy, making it unnecessary to match three pairs of deflection coils for congruence of scanning deflection as is required in the devices previously mentioned.

The new originating arrangement operates with the tridirectional faceted (Geer) screen because of coil 15. Located near the screen and carrying a direct current, it acts to converge the three divergent electron streams 16, 17 and 18 because of radial components of the magnetic field created. By adjusting the current in the coil the three streams are made to converge in the plane of screen 10. In this way, three separate electron streams, independently controllable as to intensity, can be converged at the screen as though each had come from a gun widely separated from the others and each phosphor upon the screen can be individually excited to any degree.

The author has found that this arrangement operates over a considerable area of the fluorescent screen, but not at the extremes. This can be taken care of in two ways.

Firstly, the size of the coil 15 can be increased. One of the advantages of this system is that the deflecting and converging instrumentalities are exterior to the vacuum structure and so can be altered, adjusted or replaced without

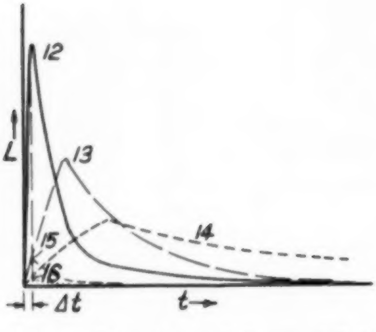

Fig. 2. The rise and decay of light output of three phosphors as a function of time; the basis of operation of cathode-ray-tube color reproducer devoid of geometrical screen structure.

affecting the most costly component, the cathode-ray tube itself.

Secondly, the magnetic axis of the coil can be inclined in synchronism with the scanning of the combined electron streams. In the figure, the two lower streams are at 120° from each other and from the upper stream. The common axis is thus inclined upward at the instant in scanning for which the figure was drawn. Coils 20 and 21 are provided to accomplish the inclination. These are wound in horizontal planes and supplied with a fraction of the vertical scanning energy. The field from these coils alters the original field, reinforcing it below, weakening it above, so that the magnetic axis is above the geometrical axis of coil 15.

With coil 22 and a companion 23 behind, the magnetic axis is also altered from left to right upon the face of the tube. Most fortunately, the converging action is constant over quite an area around the axis and precision in altering the magnetic field is not required.

After considerable further study of this subject the author evolved another method.[7] This method does away with the faceted screen, the magnetic coils and any other physical feature that would identify it as a color cathode-ray tube. The chromatic action takes place in the screen itself.

Man now knows of some two hundred chemical compounds, which, when combined with minute amounts of suitable impurities, give off cold light in return for the energy of impact of electrons. These substances are known as phosphors. By energizing suitable phosphors differently with respect to time, selective excitation of different color components of a heterogeneously constituted screen can be accomplished.

In Fig. 2, for example, curve 12 represents the excitation and decay time of zinc sulfide with a small amount of silver as the impurity-activator, the phosphor being hexagonally crystallized. It will be noted that the response and decay are rapid. This phosphor fluoresces blue.

Curve 13 is for zinc silicate, with manganous oxide as activator, rhombohedrally crystallized. The response and decay of this phosphor are average and it fluoresces green.

Curve 14 is for zinc sulfate, with manganese sulfate activator, orthorhombohedrally crystallized. The response and decay of this phosphor are slow. It fluoresces red.

For any small interval of time, such as Δt shown, the variation of response of the three phosphors is very different, even though each phosphor be impacted with the same number of electrons accelerated through the same potential in the electron gun or guns.

The response of light, *L*, is near maximum for the rapid phosphor 12. It is much less for the medium phosphor 13, with only the small area under the resulting (dashed) decay curve being effective in light output. The response is even less for the slow phosphor 14, the amplitude rising only to point 16.

Thus, if we traverse our heterogeneous phosphor screen rapidly we secure a nearly pure blue response. But what happens if we traverse such a screen

slowly; do all the phosphors light up and produce white light?

This would be true if the only property utilized was speed of phosphor response. Actually, by combining a number of processes in an additive manner it is possible to shut off the rapid phosphors.

Phosphor materials behave differently under different temperature conditions. It is possible to select particular phosphors and to give attention during the preparation of them so that, for instance, the temperature characteristic of the above-mentioned fast phosphor is such that the light output for a given excitation reduces rapidly with increase in temperature. At the temperature of boiling water the light emitted can be made only one-fifth that at room temperature.

In the present device this phosphor is, furthermore, formed in small particles—less than 10^{-3} millimeter. Small particles heat much more rapidly and attain a higher temperature than large ones. Consequently, the temperature effect is accentuated and under a slowly moving or stationary electron stream, such as is required to activate the slow phosphor; the light from the rapid phosphor has reduced to a small value.

The coefficient of secondary emission of the phosphor is similarly utilized. The coefficient of the above-selected fast phosphor decreases with increase in temperature. By selecting a proper operating potential for the gun of the cathode-ray tube in relation to the secondary emission characteristic of the phosphor the ratio of secondary emission can be made less than one. This means that the phosphor particle accumulates a negative charge under the influence of the slowly moving or stationary electron stream and ceases to glow because of the resulting lower effective velocity of impact.

Not only can these factors, inherent in the rapid phosphor and its preparation, be utilized to cause the blue light to cease shortly after time Δt when the rate of traverse of the electron stream is slower, but the rapid phosphor can be covered with a thin layer of silica, chemically deposited on the particles before the screen is fabricated. Silica has a secondary emission ratio less than one at desirable cathode-ray tube operating voltages. Metals, such as thin films of tungsten, have similar effects. These substances do not appreciably alter the effectiveness of the primary electrons of the electron stream when this impacts the phosphor during the proper brief interval of excitation.

Without going into detail, the phosphor of medium time of response is also formed in small crystals and is chosen and/or treated to cease functioning during slow traverses. It does not, of course, become appreciably excited during the rapid traverses. Should the green signal be black at any particular instant the grid of the electron gun cuts off the stream during the moderate speed of traverse.

The slow phosphor, in addition to its slow response, was selected to perform under the conditions that shut off the more rapid phosphors. It is formed of relatively large crystals that take longer to heat and of a phosphor composition that has a temperature characteristic giving visual response at high temperature and being capable of operating under slow or stationary electron streams for the brief instants utilized in the device.

These characteristics are accentuated in an alternate screen construction that includes a largely transparent, yet "black-screen" metal deposit on the inside of the glass face. This is connected to the second anode. The slow phosphor is laid down in contact with the metal. This removes any possibility of accumulating a negative charge and also provides some measure of thermal sink, preventing heating of that phosphor. The two other phosphors are deposited on top of the slow one and out of contact with the metal coating.

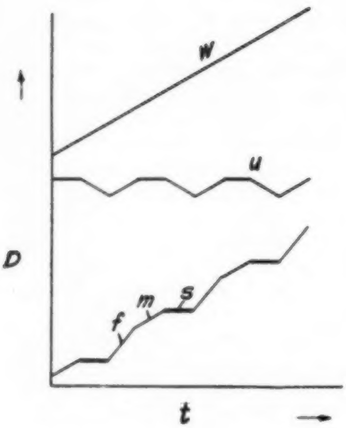

Fig. 3. Incremental waveform *u* is combined with horizontal deflection waveform *W* to secure variation of the velocity of traverse of the electron stream over the phosphors.

Experimentally, the relative amounts of each phosphor may be changed to effect chromatic adjustment. The integrated intensity of the corresponding color is thus varied. The spectral response is empirically determined, being composed of the inherent response of the phosphor and a small and fixed response of another. Not every batch of available phosphors can be used with certainty. Because the impurities of subspectroscopic amounts and the actual lattices formed vary with ingredients and the precise routine of preparing the phosphor variation of performance will be experienced unless the phosphor used is selected upon the basis of test under operating conditions.

Fast, medium and slow traverses of the electron stream over the phosphors have been mentioned. In monochrome television the scanning speed is constant over all of the visible portion of the reproduction. In the present device a high-frequency deflecting waveshape is combined with the usual horizontal deflecting waveshape to accomplish speed variation. For a three-color system, a truncated triangular wave is one shape that is used; that is, a triangular wave-shape with the tops of the triangles cut off.

This is shown in Fig. 3. Waveshape *W* represents a small portion of one horizontal scan. Displacement *D* across the field of view is represented vertically and time horizontally as the abscissa. Waveform *u* is the truncated triangular one. When these two are combined the third waveform results. Where the slopes of waveforms *u* and *W* are the same, the resulting velocity is greatest, as at *f*. When waveform *u* effects no displacement with time, the top truncated portion, the resulting velocity is medium, as at *m*. Where the slopes of waveforms *u* and *W* are equal but opposite, the resulting velocity is zero, as at *s*. Thus, the scanning spot successively travels rapidly, at medium speed and stops, all at substantially dot repetition rate.

Refinements are possible; an asymmetric truncated waveshape can be produced by attenuating the low-frequency response of the truncated wave device. The slanting truncated top then produces the stationary spot, the rapid traverse is then more rapid and the normal or medium traverse is actually executed in reverse. Also, the stiffness of the electron stream can be altered in synchronism with these incremental deflections and the ratio of velocities further increased.

Two types of devices to provide the truncated waveshape have been developed and tested. One is a resonant oscillatory circuit employing a single small triode. Two of the coils of that circuit are placed astride the neck of the cathode-ray tube and directly deflect the electron stream in the desired waveshape. The other type of device is a relaxation oscillator that gives a triangular waveshape directly. This is truncated with a diode. The resulting

wave is fed into the usual horizontal deflecting coils, into similar coils of a few turns or impressed upon deflection plates within the cathode-ray tube.

The period of each of the three portions of the truncated wave is made equal to the period of exhibition of one of the primary colors of the color system. The above-described oscillator is kept in synchronism by feeding a small amount of color change information to it.

The color image thus formed is composed of a short blue dash, a shorter green dash and a red dot successively repeated along each line of scanning in approximately the same manner as the individual primaries are reproduced side by side in the shadow mask tricolor tube.

Other phosphor combinations have been worked out so that the dot is of green rather than red hue to favor rendition of detail. Several relations between detail and color standard are possible.

Acknowledgment

The encouragement given to this work by Willet H. Brown, President of the Don Lee Broadcasting System, Hollywood, is gratefully acknowledged.

References

1. V. K. Zworykin, U.S. Pat. 1,691,324, Nov. 13, 1928.
2. Bronwell, U.S. Pat. 2,461,515, Feb. 15, 1949.
3. C. W. Geer, U.S. Pat. 2,480,848, Sept. 6, 1949.
4. A. N. Goldsmith, U.S. Pat. 2,481,839, Sept. 13, 1949.
5. John Logie Baird, British Pat. 562,168, application dated July 25, 1942.
6. U.S. Pat. application, CCRT I.
7. U.S. Pat. application, CCRT III.

Film-Spool Drive With Torque Motors

By A. L. HOLCOMB

The characteristics of torque-motor drives are described in connection with their use for take-up and feed spools in film-pulling mechanisms. A useful but limited field of application for this type of drive appears to be indicated.

In recent years torque motors have been successfully used in some applications as a drive for take-up spools replacing the older friction-drive devices, and it is the purpose of this paper to consider the relative merits of both methods with respect to performance and convenience. The term "film spool" is here used to cover all of the various types of reels and similar devices on which film or tape is wound or from which it is unwound in the process of recording or reproducing sound.

A "torque" motor is any motor which produces maximum torque at standstill and which provides a sufficiently high input impedance to allow it to be stalled without excessive current demand. Such motors may be either a-c or d-c and are usually rated on the basis of stalled torque and the percentage of operating time they may be stalled without exceeding some acceptable temperature rise. The type most used is an a-c induction motor with either three-phase or single-phase stator and equipped with a high-resistance rotor. The development of compact a-c capacitors has permitted the use of two-phase stator windings, one of which can be effectively resonated with a series capacitor, thus providing the necessary phase shift for operation from a single-phase source. Such "capacitor run" motors are more easily switched and controlled than three-phase motors and provide essentially the same operating features.

The use of torque motors as a take-up drive for film-recording equipment was experimentally considered as long ago as 1935. The motors then available for such duty were three-phase, wound rotor units and series d-c or universal-type motors. While it was found possible to operate such motors so as to provide an approach to constant film tension, it was decided at that time that the advantage realized did not justify the cost and circuit complications which were found necessary. Torque motors have been used with excellent results in many of the magnetic-tape recorders developed in recent years, and it has logically been suggested that

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the modern version of these motors would be of value in sprocket-type recorders and reproducers using 35mm, $17\frac{1}{2}$mm or 16mm films.

Film and Tape versus Flutter

Standard $\frac{1}{4}$-in. tape as now used employs a thin flexible base which conforms readily to small-diameter drums or capstans, permitting such units to operate at relatively high speeds. The base is too fragile and flexible to utilize sprockets and sprocket holes as a synchronizing means and, consequently, a friction drive to the capstan is satisfactory. Thus, without gears or sprockets, good motion can be obtained with a relatively simple mechanical filter provided the drag and take-up are smooth. Torque motors provide not only a smooth drag and take-up, but also a convenient high-speed drive in either direction which is an essential facility in most tape machines.

Motion picture film base is relatively thick and provides sufficient longitudinal rigidity and durability to withstand not only the constant small synchronizing impulses imparted by normal sprocket action, but also the high acceleration of intermittent picture motion. Synchronism between films is obtained by effectively gearing the film to the sprocket, the sprocket to the drive motor, and electrically gearing the motor to similar motors or to a common supply line. All of these gear trains present in some degree the characteristics of inertia, resilience or backlash, and the resultant unfiltered film motion is far from desirable by sound-recording standards. Thus, the mechanical filter requirements are obviously more exacting for sprocket-type film machines than for tape machines. Uneven or erratic take-up or drag can add to the total "flutter" or "wow" which must be corrected and it was one of the objects of this investigation to determine whether the substitution of torque motors as a drive for the feed and take-up spools could provide measurably better film motion than the friction-type drive when operated in conjunction with a good mechanical filter.

The flutter which may be contributed by feed or take-up spools may take any or all of four forms:

1. Low-frequency or erratic variations due to uneven friction in clutch or belt drive.
2. Sprocket-hole flutter (96 cycle/sec) due to high film tension at beginning or end of a reel.
3. Erratic shifting of the film with respect to the sprockets at "crossover" where the net tension on the film reverses.
4. Gear-train chatter due to unloading the sprocket gears at crossover.

It will later be shown that the friction drive may contribute 1, 2 and 3, but not 4, and while the torque-motor drive is not likely to contribute 1, it may contribute 2, 3 and 4.

In order to visualize the conditions existing during the transfer of a standard 1000-ft reel of film from feed to take-up spools, it may be worth while to consider some of the factors common to a constant-torque drive.

Film Tension — Constant Torque

The minimum safe take-up tension is determined by loop formation at start and is about 300 g, although somewhat less than this value may be operable. The maximum tension is determined by film breakage or sprocket-hole mutilation and is dependent to a large extent on the film path, matching of sprocket teeth and sprocket holes, the size of drive sprockets and the acceleration characteristics of the driving system. It can be stated, however, that in general the maximum tension should never exceed 2500 g. Drag tension need only be enough to prevent a full reel from coasting and 150 g minimum is satisfactory.

A standard 1000-ft reel presents approximately a 2-in. diameter spool when empty and $9\frac{7}{8}$-in. diameter when

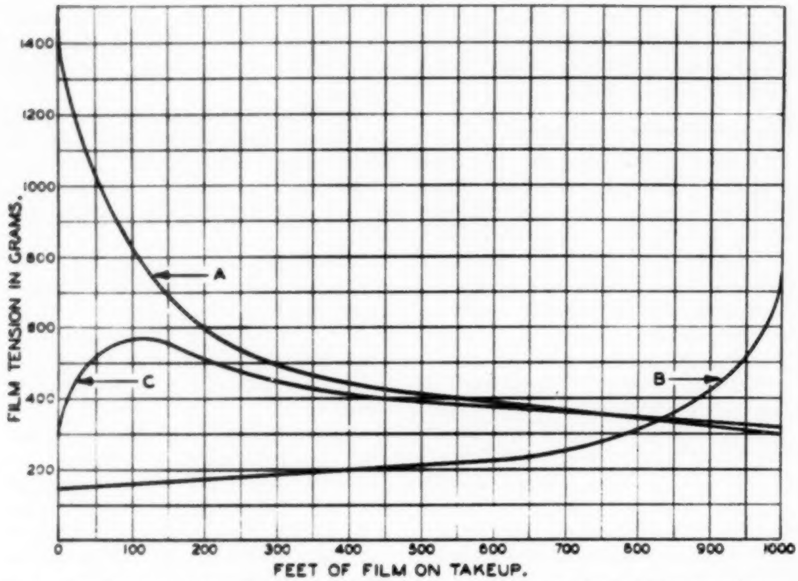

Fig. 1. Take-up and torque-motor characteristics; tension vs. feet of film on take-up.

full. Since the film speed is fixed at close to 90 ft/min, the reel speed must vary inversely with the effective diameter of the spool on which it is wound or from which it is unwound. The speed of a 1000-ft take-up reel at start is thus about 172 rpm and at the end of a 1000-ft roll is roughly 35 rpm, the feed-reel speed varying in the same manner, but inversely.

A good friction clutch, as used for this duty, delivers essentially the same torque to the driven element regardless of the differential or slip speed between driver and driven members. If the diameter of the film spool were constant, this constant torque would produce a constant pull, or tension, on the film, but the spool diameter varies from 2 in. to $9\frac{7}{8}$ in., or a ratio of 4.9:1, and as a result the tension varies by the same ratio. If the torque is expressed in gram-inches (grams pull on a 1-in. radius), and this factor is constant, then the film tension under any spool condition will equal the torque divided by the spool radius.

The film-tension conditions for a 1000-ft take-up reel (curve A) and feed reel (curve B) with 2-in. hubs are shown in Fig. 1, plotted against the number of feet of film accumulated on the take-up reel. Since the minimum take-up tension of 300 g is desired, it is assumed that the friction of the take-up clutch has been adjusted so that this tension is obtained with a full reel (radius 4.94 in.), and the torque which will remain constant is then 1480 g-in. ($300 \times 4.94 = 1480$). The minimum spool radius of 1 in. increases the tension to 1480 g. It will be noted that reel speed and film tension are directly related and both are inverse functions of spool radius. Thus, the two curves showing film tension from the feed reel, B, and from the take-up reel, A, are similar, but reversed. The minimum drag tension, as shown, is set at 150 g. It will be apparent that most of the

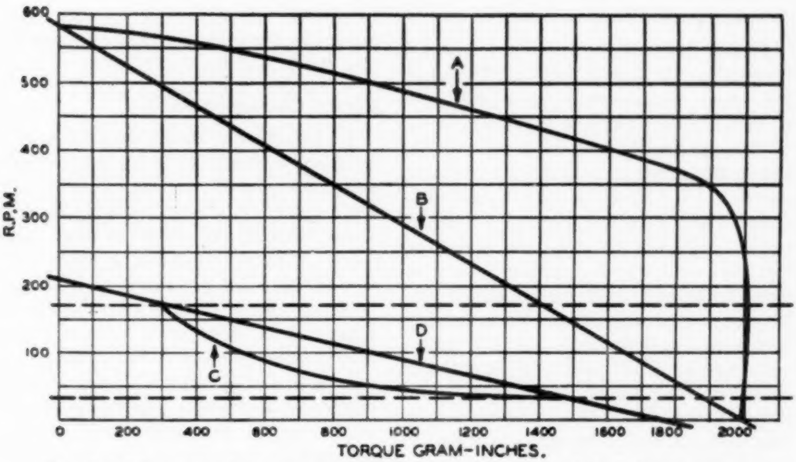

Fig. 2. Take-up and torque-motor characteristics; speed (rpm) vs. torque.

tension change occurs when the hub radius approaches minimum, and demonstrates that the use of reels with 4-in. diameter or larger hubs would materially reduce the tension ratio. Curve C of Fig. 1 will be referred to later in connection with Fig. 2.

It has generally been accepted that 2000-ft and larger reels present a more difficult take-up problem than the standard 1000-ft reel with a 2-in. hub. This is true only with respect to inertia since 5-in. hubs are generally used on the larger reels and the ratio of minimum and maximum diameters and film tensions is more favorable for such reels up to 6000 ft (ratio 4.8:1) than is the case in 1000-ft reels. The inertia, however, increases approximately as the 4th power of the film-spool diameter and, consequently, the torque required to prevent loop formation at start becomes excessive except as a smooth and slow-starting drive system is employed.

"Crossover" occurs in the region where the drag tension equals and then exceeds the take-up tension and due to the high-tension ratio (nearly 5:1) of a 2-in. hub, this condition cannot be avoided with a constant-torque drive.

With well-matched sprocket teeth and sprocket holes and a film path which provides a considerable belt effect between the film and the body of the sprocket, the film motion, with respect to the sprocket, suffers very little due to the change in direction of the net tension; but a flutter condition can exist due to gear chatter if the crossover removes the load from the sprocket-driving gears and drive motor. This condition can occur with torque motors, but when a friction-clutch take-up is driven from the sprocket shaft it is usual to provide an overdrive of about 20% above the maximum reel speed. This presents a friction load on the gear train and motor at all times, regardless of tension between the take-up reel and sprocket, which is in the same direction as the drag from the feed reel. Thus, a friction-clutch take-up will normally present a film tension crossover, but if properly designed will not unload or reverse the torque on the take-up sprocket and motor gears. To realize fully this advantage in a dual sprocket drive, the holdback sprocket should also be damped or loaded.

Torque-Speed Characteristics

Figure 2 shows torque-motor characteristics at A and B, and at C shows the ideal torque-speed curve required to provide constant film tension from a 1000-ft reel with 2-in. hub. Curve A shows the relation between torque and speed of a 12-pole torque motor frequently used as a direct drive for take-up reels. For take-up duty the speed of the reel and of the torque motor is determined by the film speed, and it will be noted that the dotted lines carried out from the minimum and maximum reel speeds of 35 and 170 rpm both intersect the motor characteristic at about 2000 g-in. Thus, the torque of this unit, as normally used, is constant and behaves in the same manner as does a friction clutch. Ideal torque-motor characteristics shown by the straight line B, drawn from stall torque to free speed, would be some improvement but would still fall far short of matching the curve C.

The stall-torque or zero-speed point of either A or B can be moved toward zero torque by various means such as series resistance, but the no-load speed is chiefly a function of the number of poles in the motor and, thus, it becomes apparent that even an approximation of curve C will require either a 36-pole motor or approximately a 3:1 mechanical-speed reduction. The characteristic D can be obtained in this manner and while it does not provide constant tension due to the curvature of C, it is an approach thereto, as shown in C of Fig. 1. The latter is replotted from curve D in terms of film tension on a take-up reel driven by a 12-pole torque motor with a 3:1 mechanical reduction, and represents the best relationship that can be obtained between film tension and number of feet of film on the take-up with a torque-motor drive. However, this destroys the ability for fast runback except as a gear change is employed, and spoils the mechanical simplicity which is one of the most attractive features of torque motors for this duty.

Flutter Characteristics

In Fig. 3A the total flutter of a very good tape machine is shown without automatic speed correction and the same record is shown in Fig. 3B with speed correction. The average rms value for either condition is about 0.06 or 0.065%. This relatively low average of total flutter is a good example of what can be done with a simple filter and torque motors when gears and sprockets are eliminated. An attempt was made to produce approximately the same type of drive and filtering action as obtained in the tape machine, but substituting a 16-tooth sprocket as a drive member together with the necessary gears. Torque motors were used for drag and take-up duty and the drum near which the recording head was located carried a substantial flywheel. The resultant flutter from a very good record is shown in Fig. 3C. It will be noted that the average flutter is somewhat greater than that of the tape machine, and shows considerable low-frequency variations and erratic characteristics not present in the tape record. These flutter charts are made on a time axis in which one division equals one minute and in which the vertical ordinates represent 0.01% peak or 0.007% rms flutter for each small division.

The performance shown at C probably represents as good motion as could be obtained from synchronously driven 35-mm film with a mechanical filter such as is used in the best magnetic-tape machines. The take-up and drag tensions on the film machine were adjusted to be the same as shown in Fig. 1. Although 5-in. hubs were used, some evidence of high take-up tension will be noted at the beginning of the reel, although the increase of drag tension at the end of the reel does not reach a

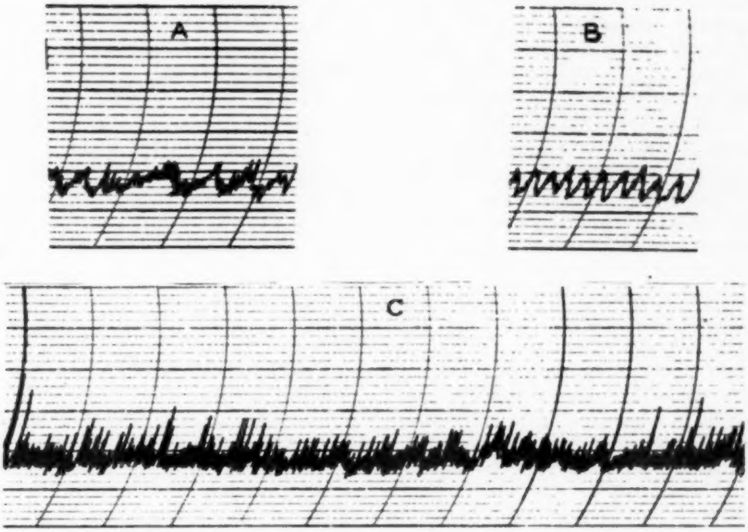

Fig. 3. Flutter characteristics. A and B, tape machine; C, 35mm sprocket machine.

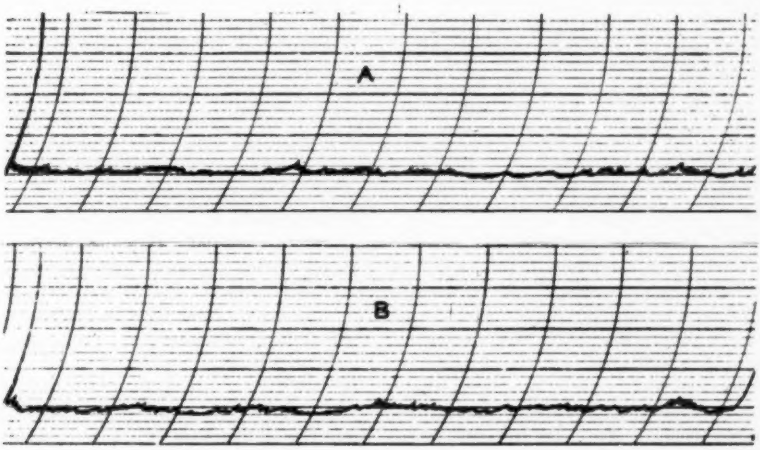

Fig. 4. Flutter characteristics — 35mm sound recorder. A, friction take-up and drag; B, torque-motor take-up and drag.

sufficiently high value to be significant. An increase in the number and amplitude of erratic excursions toward the end of the record shows the effect of crossover.

Figure 4A is a chart made using the same record as in Fig. 3C reproduced on a standard Westrex RA-1467-A Recorder, described by Crane, Frayne and Templin,[1] with sprockets and mechanism as described by Davis.[2] This machine was not given special treatment other than a check to insure normal operation of all elements. In Fig. 4B is shown a similar chart made from the same record on the same machine, but with torque-motor take-up and drag. Within the accuracy of measurement, which is about 0.005%, the two charts are essentially similar, neither one showing any adverse effects from crossover or other take-up disturbances. An analysis of the flutter under the two conditions is practically identical and is shown in Table I, neglecting those frequency bands where the measured values are less than 0.01% rms.

Table I.

Cycles	Per cent rms
1–200	0.035
130–200	0.021
80–130	0.014
50–80	0.010
34–50	0.010
4½–7	0.010
1–2½	0.014
0–1	0.010

Using the torque-motor take-up, a considerable number of tests were made with various values of constant tension and constant torque. The results indicated that with this particular recorder the filter system was adequate to eliminate undesirable effects of crossover or variations in film tension up to about 2000 g. Thus, as far as this production recorder is concerned, it would appear that a good friction-clutch take-up driven by a reasonably smooth belt is capable of delivering essentially the same flutter performance as when equipped with torque motors.

Operational Features

Torque motors, however, do have a number of advantages, for certain specific duties, which the friction drive cannot supply. They are readily operable in both directions by simple switching, at slow speeds for normal recording, or at high speeds for fast rewind in either direction. They are also capable of being controlled to provide constant tension if such control is deemed necessary, and where 1000- and 2000-ft reels are used interchangeably they can be switched to provide the proper torque for either condition. They also have a further advantage, that if they are conservatively engineered for the job so that they do not overheat, there is little, if any, maintenance required. However, torque motors are inherently slow in response, due to a poor torque-inertia ratio, and they should be equipped with electromechanical brakes to prevent coasting and to provide some rigidity of the reels for threading operations when the drive power is off, because when film is allowed to develop appreciable slack, torque motors are likely to break film or tear sprocket holes when the motors are excited and this slack is taken up. Such motors are, in effect, a separate motor system which requires additional controls of some complexity if the desirable features are to be realized. Also, the weight of a pair of these motors, together with the necessary control equipment, will add at least 25 lb to any 35mm machine on which they are installed.

Conclusion

For production recording in which experience indicates that it is seldom necessary to run forward or back at high speeds, it does not appear that torque motors contribute features which justify the added weight, bulk, and

control complication. For re-recording, however, high-speed operation in either direction is a desirable feature and the additional weight and bulk in such stationary equipment is unimportant.

References

1. G. R. Crane, J. G. Frayne and E. W. Templin, "A professional magnetic-recording system for use with 35-, 17½- and 16-mm films," *Jour. SMPTE, 56:* 295–309, Mar. 1951.
2. C. C. Davis, "An improved film-drive filter mechanism," *Jour. SMPE, 46:* 454–464, June 1946.

Discussion

Col. R. H. Ranger: Some time since, we worked on torque motors for tape machines, but I'm very much interested in this application to 35mm. Isn't it true that the reverse characteristic of a torque motor applies only in the direction in which it is trying to drive? In other words, if you use it as the release motor, why, it will not at all have the same characteristics as it does for the take-up. In our work we use a torque motor with a high-resistance rotor for the take-up, but for the release we found that d-c, applied to an ordinary induction motor, gave very much more the characteristics that we wish; in other words, you get a very uniform inverse ratio of torque to diameter with that kind of a setup. Is that not correct?

A. L. Holcomb: The characteristics do vary. However, when we use a 12-pole motor with a characteristic similar to that shown in Fig. 2 (curve A), the torque is essentially the same ±172 rpm as it is at standstill. As noted in this paper, such a motor is a constant torque device over the range of reel speeds.

Col. Ranger: As it goes through the zero point, the action is entirely different, the curve is practically flat, in the reverse direction. Whereas if you use d-c on the winding of an ordinary induction motor, you get a very nice inverse curve.

Mr. Holcomb: That's true.

Col. Ranger: And it has the decided advantage that it gives you high-speed rewind; and so it gives you, I might almost say, all the things you want.

Mr. Holcomb: That is quite true. You would get a slightly better characteristic with d-c, for drag duty, than you would when reversing the direction of rotation against a-c torque. This difference may well be worth while for tape machines, but for sprocket-type machines, the difference in performance is not apparent.

Col. Ranger: Plus the opportunity to have a d-c brake.

Mr. Holcomb: Yes, a brake appears to be very necessary. For sprocket machines a "normally on" electromechanical brake seems preferable in order to provide some reel stiffness during the threading operation when there may be no electrical excitation.

Heat-Transmitting Mirror

By G. L. DIMMICK and M. E. WIDDOP

Radiant energy incident upon a glass plate can be divided into transmitted and reflected bands by the interference effect in thin films of dielectrics deposited on the glass. The mirror described here reflects over 95% of incident visible light and transmits a large part of the energy beyond 7000 A. Such mirrors have been produced and typical transmission characteristics are shown. Several arrangements for use of such a mirror with a carbon arc are also shown.

THE PROBLEM of producing "cold light" has occupied the attention of scientists and engineers for many years. A number of methods have been successfully employed for reducing the relative amount of radiant energy which lies outside the visible spectrum. One approach to the problem is to employ a light source which radiates a large portion of its energy in the visible spectrum. The fluorescent lamp and the mercury-vapor lamp are examples of this type of source. Unfortunately, the unit brightness of the fluorescent lamp is too low to have much application in optical systems of the projection type. Fluorescent lamps are, however, used extensively for general lighting where the area of the source can be relatively large. High-pressure mercury-vapor lamps are capable of producing large values of brightness, but they are deficient in red energy, and a large part of their radiation is concentrated in a number of discrete lines. The addition of cadmium vapor into a mercury-vapor lamp greatly improves the distribution of energy in the visible spectrum and makes this type of lamp a potential competitor to the carbon-arc and the incandescent lamp for application in projection-type optical systems.

Another approach to the problem is to employ a carbon-arc or incandescent light source and to remove as much of the infrared energy as possible with the aid of absorption filters or with heat-reflecting mirrors. Absorption filters may be made of special heat-absorbing glass or they may be cells covered on both sides with ordinary glass and having a liquid, such as water, flowing continuously through them. The heat-absorbing glass filters usually require a current of air to flow past the two surfaces to carry away the heat. A well-known type of heat-reflecting mirror is produced by evaporating a thin film of gold onto one surface of a plate of glass. The thickness of the gold may be

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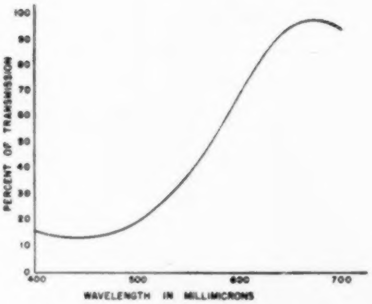

Fig. 1. Transmission curve of a typical dichroic.

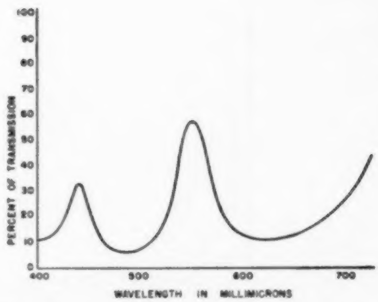

Fig. 2. Transmission curve of dichroic consisting of two sets of layers.

such that its transmission is maximum for green light and its reflectivity is high in the infrared region of the spectrum. Heat-reflecting mirrors of this type have a very limited application because the transmitted light is peaked in the green and the transmitting efficiency is low even at its peak.

Still another approach to the problem is to use the principle of interference in thin films to build up the reflectivity for light within the visible spectrum and to permit the infrared energy to be transmitted. It is toward this solution to the problem that the present paper is directed. The use of multiple films for the production of dichroic mirrors has been covered in the literature and will not be described in detail here. It is sufficient to say that efficient dichroic mirrors may be made by evaporating on glass alternate layers of two transparent dielectric materials, one of which has a relatively high index of refraction while the other has a lower index of refraction. The thickness of each layer is usually made to be $\frac{1}{4}$ wavelength for light of the color which is to be reflected. It is possible to make dichroic mirrors which reflect as much as 95% of the light of one color and transmit 90% or more of the light of another color. A typical curve for a dichroic reflector is shown in Fig. 1. The peak reflection occurs at about 450 mμ while the peak transmission occurs at about 650 mμ.

One of the important characteristics of a dichroic reflector is that the absorption of visible and infrared radiation can be made negligibly small. This means that radiation which is not reflected from the multilayer film is freely transmitted through this film. It was this property which gave the authors the idea for a heat-transmitting mirror which would reflect efficiently only in the visible portion of the spectrum. The idea was to deposit several sets of multilayer dichroic films on the surface of a plate of glass. Each set would be so controlled as to cause its peak reflection to occur at a different wavelength. The peaks would be equally spaced through the visible spectrum so that all portions of this spectrum would be reflected efficiently. Light which did not reflect from the outermost dichroic film would pass through this film to one of the inner films, where it would be reflected and would then pass back through the outer films to the surface.

The first test of the idea was made several years ago in an RCA Advanced Development Laboratory in Indianapolis. Two sets of dichroic films were deposited in succession on the surface of a plate of glass. The thickness of the layers of one set was so controlled

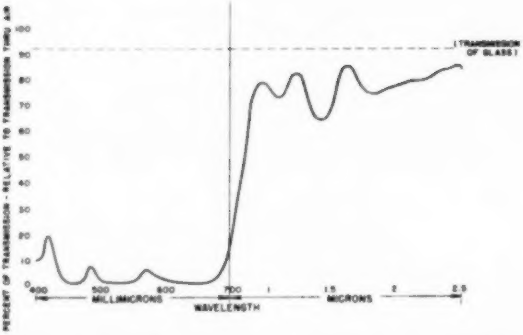

Fig. 3. Transmission characteristics of a heat transmitting mirror.

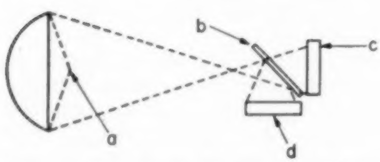

Fig. 4. Setup used for measuring heat transmission and reflection of mirror.

as to make the peak in reflectivity occur at 490 mμ. The other set of layers was made to have its peak in reflectivity at 650 mμ. The transmission curve of the completed mirror is shown in Fig. 2. As expected, a curve with a double hump was produced by the above procedure and the efficiency of the reflector was greatly improved. The results of the first tests were so encouraging as to warrant a systematic study of the different parameters upon which the overall effectiveness of a heat-transmitting mirror is based. Development work on this project continued intermittently for several years. The improvements which were made resulted in mirrors having a degree of reflectivity which is greater than that of a back-silvered glass mirror.

The curve in Fig. 3 shows the transmission of one of the improved designs as a function of wavelength. It will be observed that the average transmission from 400 to 700 mμ is less than 10%. Since there is no appreciable absorption, this means that the average reflectivity over the visible spectrum is more than 90%. Beyond 700 mμ, the transmission rises rapidly. The average transmission between 700 mμ and 2.5 μ is about 80%. Since most of the energy from a high-intensity carbon arc is below 2.5 μ, the transmission characteristics of the heat-transmitting mirror beyond that wavelength are not shown in Fig. 3. However, the transmission has been measured out to 8 μ, and shows a sharp drop just beyond 2.5 μ. The average transmission between 2.75 and 4.25 μ is about 50%. Beyond 4.25 there is another sharp drop and the transmission from 5.25 to 8 μ is about 1%. The first drop in transmission is characteristic of absorption due to water vapor, and the second is characteristic of absorption of glass. It is unlikely that there is appreciable reflection by interference at this part of the spectrum, since the deposited films are thin in comparison to the wavelength.

The effectiveness of the heat-transmitting mirror was determined by measurements made with the arrangement shown in Fig. 4. A beam of radiant energy from a high-intensity arc lamp, a, was directed toward the heat-transmitting mirror, b, placed at an angle of 45° with the axis of the

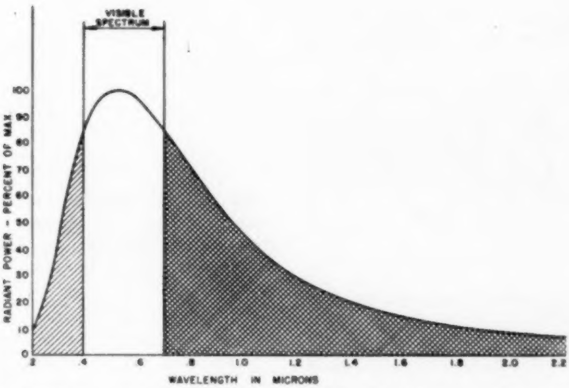

Fig. 5. Radiant power vs. wavelength for blackbody operating at 5500 K.

beam. A portion of the energy passed through the mirror and was absorbed by a black solution in the liquid cell, c. The remainder of the energy was reflected from the mirror, b, and was absorbed by a black solution in liquid cell, d. The liquid cells were identical in size and each contained the same amount of a mixture of water and India ink. An accurate thermometer was placed in each cell and the liquid was allowed to come to room temperature before turning the arc lamp on. The arc lamp was started and allowed to stabilize after which the shutter was opened. The liquid in both cells was stirred constantly and temperature readings were taken once each minute for ten minutes. The temperature readings from both cells were plotted against time, and a smooth curve was drawn through the points. Straight lines were drawn tangent to each of these curves at the starting point, where the liquid was at room temperature. The slope of each of the straight lines is proportional to the rate of absorption of energy. The ratio of the two slopes is, therefore, a measure of the ratio of the total energy reflected from the mirror to the total energy transmitted through the mirror. In the case of the high-intensity arc, the above measurement revealed that 46% of the total energy was transmitted, while 54% was reflected. Another measurement made with a 750-w incandescent lamp as a source revealed that 75% of the total energy was transmitted, while 25% was reflected. These measurements were made with the mirror at 45° for convenience. A test was made to determine the change in transmitted energy when the position of the mirror was shifted from 45° to normal-to-the-beam. There was no significant change.

The energy reflected from the mirror may be divided into two parts. The first part is due to the useful visible light between the limits of 400 and 700 mμ. The second part is the unwanted infrared energy which the mirror fails to transmit. The first value can be obtained from a curve of radiant power versus wavelength for the light source operating at a temperature of 5500 K. This is the approximate color temperature of a high-intensity carbon arc of the type used for motion picture projection. By measuring the area under the whole curve in Fig. 5 and comparing this with the area under the visible portion only, it is found that about 35% of the total energy from a high-intensity arc is radiated within the visible spectrum. Using this value, together with

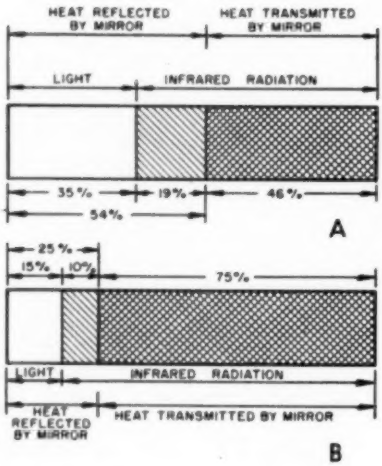

Fig. 6. Distribution of energy by reflection and transmission using heat-transmitting mirror: A, high-intensity carbon-arc source; B, incandescent-lamp source.

the previously obtained values of total reflected and transmitted energy, we can easily determine the overall performance of the heat-transmitting mirror. This is shown by means of a chart (Fig. 6). From this it may be seen that the mirror transmits more than two-thirds of the unwanted heat due to infrared radiation. It transmits nearly half of the total radiation with a loss of less than 10% of the visible light.

When used with an incandescent source, the performance of the heat-transmitting mirror is even more impressive. In this case, 75% of the total energy of the lamp is transmitted through the mirror with a loss of less than 10% of the visible light. A gas-filled incandescent lamp operating at a color temperature of 3000 K radiates about 15% of its energy in the visible spectrum between 400 and 700 mμ. Nearly 85% of its energy is radiated in the infrared region between 700 mμ and infinity. The second chart in Fig. 6 shows how the heat-transmitting mirror performs when the light source is an incandescent lamp. About 88% of the unwanted heat energy due to infrared radiation is removed by the mirror. Seventy-five percent of the total heat energy is removed, with a loss of less than 10% of the visible light.

The heat-transmitting mirror might be used in a number of ways to reduce the temperature of the film as it passes through the gate of a motion picture projector. Figure 7 shows an arrangement in which multilayer films replace the usual silver reflecting layer on the convex surface of the reflector in a motion picture projector. The glass reflector shell, c, has its convex surface, a, coated with the evaporated films which transmit a large part of the heat and reflect most of the light. A corrugated metal shell, b, encloses the back of the reflector and is spaced away from the evaporated films. This metal shell serves the double purpose of protecting the reflecting surface from contamination or mechanical damage, and absorbing the radiation so that the energy may be dissipated by convection currents.

One possible disadvantage of the scheme shown in Fig. 7 is that elaborate and expensive equipment might be required to evaporate thin films with the required uniformity on the convex surface of the reflector. This disadvantage would be overcome in the arrangement shown in Fig. 8. Here

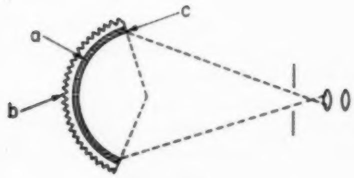

Fig. 7. Sketch of projection optics using a heat-transmitting film on back surface of reflector.

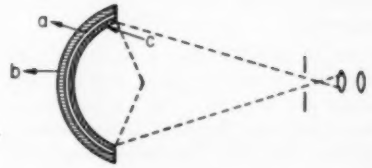

Fig. 8. Projection optics using heat-transmitting film on front surface of reflector, protected by another glass.

the multilayer film, a, is on the concave surface of the reflector where it would be relatively easy to obtain the required uniformity. In order to protect the surface from contamination and mechanical damage, a thin-glass shell is placed in front of the reflector and in contact with it all along the rim. This shell might be removed for cleaning, and it could be replaced when its concave front surface gets badly pitted by hot particles from the carbon arc.

Still another arrangement of the heat-transmitting mirror is shown in Fig. 9. The evaporated films, a, are placed on the back surface of a flat plate of glass, c. A thin, corrugated-metal housing encloses the back of the reflector and keeps it clean and free from mechanical damage. The heat is dissipated by convection currents of air flowing past the thin metal housing. This arrangement, with a single heat-transmitting mirror and a normal silver-backed concave mirror, requires a right-angle bend in the illuminating system. If this is a disadvantage, it could be overcome by the use of two heat-transmitting mirrors like those shown in Fig. 9, arranged to make an offset system with two right-angle bends. This would result in a two-stage heat filter which would be even more effective than shown by the charts in Fig. 6. If desired, a two-stage heat filter could also be obtained by using a combination of the systems shown in Fig. 7 or Fig. 8 with the system shown in Fig. 9.

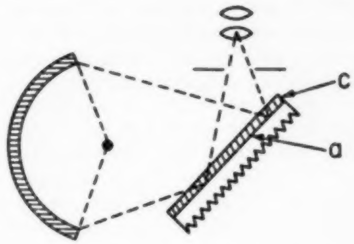

Fig. 9. Flat heat-transmitting mirror used in beams from silvered reflector.

References

1. J. Strong, "On a method of decreasing the reflection from nonmetallic substances," *J. Opt. Soc. Am.*, *26:* 73–74, Jan. 1936.
2. C. H. Cartwright and A. F. Turner, "Multilayer films of high reflecting power" (Abstract), *Phys. Rev.*, *55:* 1128, June 1939.
3. G. L. Dimmick, "A new dichroic reflector and its application to photocell monitoring systems," *Jour. SMPE*, *38:* 36–44, Jan. 1942.
4. G. J. Koch, "Interference mirrors for arc projectors," *Jour. SMPTE*, *55:* 439–442, Oct. 1950.

Discussion

Frank Carlson: What is the maximum temperature the mirrors will stand?

P. J. Herbst: No tests have been made to determine the maximum temperature the mirrors will stand. No damage has resulted from tests using the mirrors in the beam from a high-intensity arc.

D. B. Joy: Has it been found that these films will stand up satisfactorily in ordinary

projection lamps used in motion picture projection?

Mr. Herbst: The mirror has been subjected to the beam from a high-intensity carbon arc, focused to about a 3-in. diameter spot, for several hours without damage. However, actual life tests have not been made on the mirrors.

Mr. Joy: The Motion Picture Industry should be grateful to you people for having done some work along these lines. We are faced with a very practical and immediate problem of trying to keep the heat down on the film, while we are trying to force a great quantity of light through the film in out-door theaters. Therefore, anything along this line, coming at this time, will be of great help in giving us better movies, and that's the thing we want.

Mr. Strickland: If you don't have the shield in front of the mirror, and you get pretty well pitted, does that have the tendency to lower your light?

Mr. Herbst: You mean the dichroic on the front of the mirror next to the carbon arc?

Mr. Joy: That's right.

Mr. Herbst: This would not be recommended. The dichroic surface should be protected.

Recent Improvements in Silencing Engine-Driven Generators

By L. D. GRIGNON

A gasoline engine-driven, 120-v, d-c generator of 150-kw output for set lighting on location has been improved. The enclosing wall structures, materials and carburetor air-intake were changed. When mounted on a trailer the exhaust and radiator and noise are considerably reduced by methods described. The improvements permit sound recording with the generator as close as 250 ft under reasonably favorable circumstances and not exceeding 750 ft for critical conditions. Considerable saving in production costs results.

The silencing of noisy equipment used in the production of motion pictures has been a continuous problem since sound recording became a part of the industry. One of the most offending equipments has been the engine-driven generator used for set lighting on location, although the accumulated contributions of many workers have produced considerable improvement over the initial situation.

The problem which led to the improvements reported herewith was posed as follows: Given a gasoline-engine-driven, direct-current generator set of 150-kw capacity of the basic design described by Hankins and Mole[1] and of similar size, what changes or modifications can be made to obtain a plant with less noise?

The difficulty in work of this kind is to find the best compromise between size, weight, cost, operating features and quietness. As is well known, quietness is not compatible with the first three items.

The design previously produced by the Mole-Richardson Company was carefully studied with these conclusions: that some change in structure shape would permit mounting the engine and generator on a noise-insulated subbase; that it was reasonable to expect improvement in wall design; and that better sound absorptive materials might be used. The design of the subbase was undertaken by the Mole-Richardson Company with the application of conventional vibration insulation methods. Further, in consultation with the same company and the engine manufacturer, it was concluded that the engine could be completely enclosed and adequately cooled by water only.

The next step, in order, was to consider the enclosing structure. Figure 1 illustrates the basic layout.

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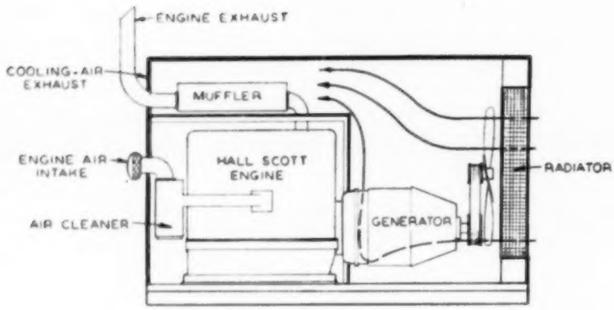

Fig. 1. Basic plan of enclosure.

Three principal factors determine the efficacy of sound-insulating structures. These are absorption, transmission through the various media and element resonance. When the maximum amount of absorption at the sound source can be provided, the two latter problems are somewhat simplified. Of first importance, therefore, is the selection of absorptive materials for the inside surfaces of the enclosing structure. Again, a balance of thickness, weight and absorption must be determined and, to complicate matters, the material must be fireproof in this particular application.

A material having a good balance of these factors is known commercially as Spraycoat. This is a shredded asbestos material with a suitable high-temperature flameproof binder. It is applied by spraying and tamping, preferably on wire mesh or plaster wire. If some air space is provided behind a $\frac{3}{4}$-in. layer of this material, very good low-frequency absorption is attainable and since it is of a semiporous soft nature, the high-frequency absorptive qualities are excellent. Whenever the material is applied in this manner, the support must be reasonably taut in order that the tamping operation will be satisfactory. The material is not mechanically strong and in areas where this is of importance it is desirable to protect the surface with wire mesh. An additional mechanical help is to spray the surface with a thin application of water-base casein paint.

Wherever possible, the interior surfaces of the enclosing structure have been covered with Spraycoat. In a few specific instances, for mechanical reasons, an air-duct felted material with an asbestos-cloth facing known as Dux-Sulation has been used.

Panel or structure resonance is of great importance for, if resonance exists, the structure will apparently have small transmission loss in contradiction to the predicted loss value based on the materials used. One method used in the past for minimizing resonance consisted in designing the panels in random sizes. This is of value in that such resonances as do exist are distributed in the frequency spectrum and the added bracing provides some damping. A better solution would be some method which eliminated resonance, regardless of the panel spectrum distribution. This implies that damping is the important factor and accordingly design effort was directed to this specific aspect.

The most generally used panel-damping method is the application of non-hardening asphaltic or rubberlike materials. These do provide some damping and lower the panel-resonance frequency by virtue of the added weight, but in many ways this method is not very satisfactory. The most favorable

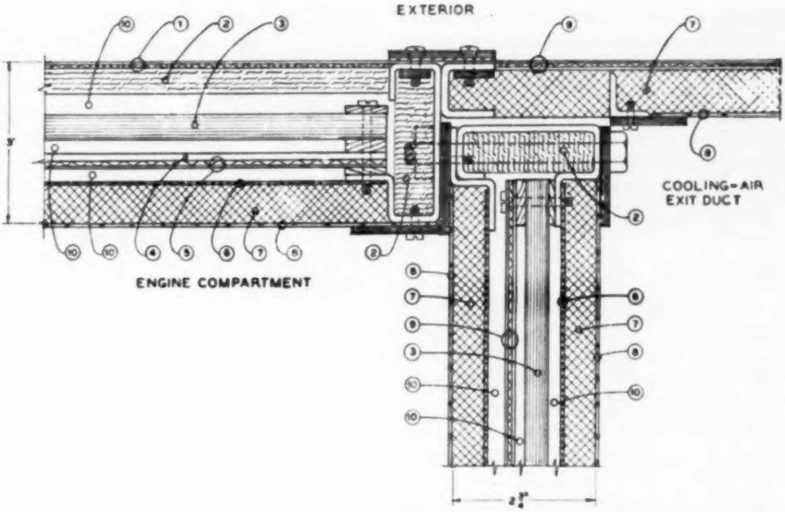

Fig. 2. Types of wall sections showing juncture of engine compartment and cooling-air exit duct.

1. Stainless-steel, 20-gauge Type 302 plus 2 layers Brownskin building paper cemented with Minn. Mining EC-1025.
2. Dux-Sulation $\frac{1}{2}$ in. thick cemented with Dux-Sul Glue.
3. Celotex $\frac{1}{2}$ in.
4. Minn. Mining Undercoater EC-831, $\frac{1}{8}$ in. thick.
5. Aluminum 0.040 2S plus 1 layer Brownskin Grizzly Bear 30/40 building paper cemented with Minn. Mining EC-1025.
6. Metal Lath 3.4 lb.
7. Spraycoat $\frac{3}{4}$ in.
8. Hardware cloth 17-gauge, $\frac{1}{8}$ in. × $\frac{1}{8}$ in. mesh.
9. Stainless-steel, 20-gauge Type 302 plus one layer Brownskin Grizzly Bear 30/40 building paper cemented with Minn. Mining EC-1025 to steel and 0.040 aluminum 2S.
10. Air space.

aspect of the so-called "undercoaters" is low cost. Certain heavy, creped building papers have been found to provide excellent damping when cemented between two panels in laminate form. In such form, panel vibration establishes sheer forces within the damping paper which dissipates the energy. A single metal sheet with cemented paper is reasonably well damped and may be used, when indicated, with good results.

With good damping and high absorption attained, attention may be directed to the reduction of sound transmission. The classical considerations of transmission loss now more nearly apply in the practical case by virtue of the significant reduction in resonance. It is known that two separate structures have greater transmission loss than the same total amount of material in one structure, but this scheme complicates the construction, makes for increased size, increased weight, difficulties of access and maintenance. Wall structures with air spaces also provide more transmission loss than the same amount of material in a solid wall, but are

usually more conservative of space than the separate wall design, although lower attenuation can be expected. An additional factor to be considered is that motion picture dialogue sound recording is usually attenuated at the low-frequency end relative to midband and a high-pass filter is used. It is, therefore, illogical to provide high attentuation below 100 cycles.

Wall Sections

Considering all items discussed above, wall sections as shown in Fig. 2 were devised. The illustration shows the joint between three different sections as follows: the left-hand section between the engine compartment and the outside; the right-hand section between the cooling-air exit duct and the outside; and the vertical section between the engine compartment and the cooling-air exit duct. The materials are shown in the illustration, but the outer skin requires more explanation.

For durability and appearance the outside material is stainless steel damped with two layers of creped building paper. Since the paper is creped in only one direction and light in weight, two layers at right angles give good damping. The paper is cemented together and to the metal with a Minnesota Mining nonhardening adhesive. The single metal-paper laminate is used in this location because it is desirable to face the inside surface with an absorptive material to minimize reflections in the adjacent air space and to lower the unit weight of the section.

Both the air duct and the engine compartment must be faced with highly absorptive material. Because of a dimension limitation, the wall between these regions is modified slightly to include a metal-paper-metal laminate panel. The use of the metal-paper-metal laminate maintains the transmission loss at a suitable value which would otherwise have been decreased, due to the removal of the damped aluminum panel used in the other principal wall section. Obviously, the air-duct wall requirements are considerably less severe, so here the principal attenuation is provided by a metal-paper-metal laminate with Spraycoat applied directly on the inside.

The actual attenuation of the main wall sections is not precisely known due to a lack of facilities for this type of measurement. By calculation and considered judgment, it seems reasonable to assign an attenuation value of 43 to 50 db at midband and somewhat less at 100 cycles. The attentuation is, however, ample, since by methods to be mentioned later whereby the residual noise is considerably reduced, noise through the wall sections is still far below all other sources.

As a matter of refinement and precaution, all structural members are filled with Dux-Sulation. It will also be noted in the illustration that the wall section can be disassembled from the outside if it is necessary for any reason.

Doors for access to the equipment are a necessity and in the past the most popular idea has been to use a stepped jamb with multiple rubber or felt gaskets and a latch which compresses the frame and jamb upon the gaskets. This construction is commonly known as the "icebox door." This method is satisfactory as a sound-stopping scheme, but is cumbersome, requires heavy hardware and loses effectiveness as the gaskets are damaged or deteriorate with age. If a door is made with sufficient accuracy so that the residual crack is of small dimensions, only high frequencies will be transmitted by this path. Further, high frequencies are readily absorbed by many different materials, so that any material which can be introduced within the residual crack will considerably reduce the high-frequency transmission. This is the basic design idea used in the subject project, and the actual construction is shown in Fig. 3. The design requires no especially heavy

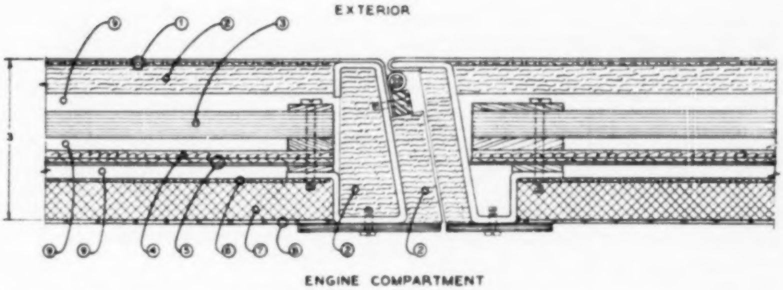

Fig. 3. Section of engine compartment wall including access door construction.

1. Stainless-steel, 20-gauge type 302 plus 2 layers Brownskin building paper cemented with Minn. Mining EC-1025.
2. Dux-Sulation $\frac{1}{2}$ in. thick cemented with Dux-Sul glue.
3. Celotex $\frac{1}{2}$ in.
4. Minn. Mining Undercoater EC-831, $\frac{1}{8}$ in. thick.
5. Aluminum 0.040 2S plus 1 layer Brownskin Grizzly Bear 30/40 building paper cemented with Minn. Mining EC-1025.
6. Metal lath 3.4 lb.
7. Spraycoat $\frac{3}{4}$ in.
8. Hardware cloth 17-gauge, $\frac{1}{2}$ in. $\times$ $\frac{1}{2}$ in. mesh.
9. Air space.

hardware, no pressure is required to close the door and there is no audible noise transmission through the door joint. The gasket shown serves principally as weather stripping and makes the final closure of the door crack. If the crack can be held to $\frac{1}{16}$ in. or less by good construction, about a 40-db noise attentuation can be expected. An empirical rule to estimate the loss through a joint as shown is to allow 1 db for each unit of sound-path length, the unit being equal to the crack width.

As is apparent from Fig. 1, the generator compartment is open to the air through the water-cooling radiator and, therefore, it would be poor design to provide the same excellent wall structure for this volume as was used for the engine compartment. Accordingly, the wall structure used in these areas was the identical simple section of the exit air duct.

Air Exit Duct and Mufflers

The cooling-air exit duct is of interest in that no baffles or turns are used. The duct is straight and open from the generator compartment to open air, a distance of 63 in. Two vertical separators are placed in the duct to provide more surface for absorptive Spraycoat.

The duct has cross-section dimensions of 15 in. $\times$ 50 in. and absorbs the generator and fan noises so well that this potential source of noise needs no other attention.

Several good engine-exhaust mufflers are available, hence the only precaution to be observed on this item is that the muffler itself does not become a noise source. This difficulty can be minimized by wrapping the muffler with sheet asbestos held tightly to the muffler surface with an external wrap of sheet metal.

Carburetor Intake

A situation contrary to that of the engine exhaust concerns the engine carburetor air-intake. If outside cool air is to be used for the engine, then the noise from this source needs considerable attention when, as in this case, the other

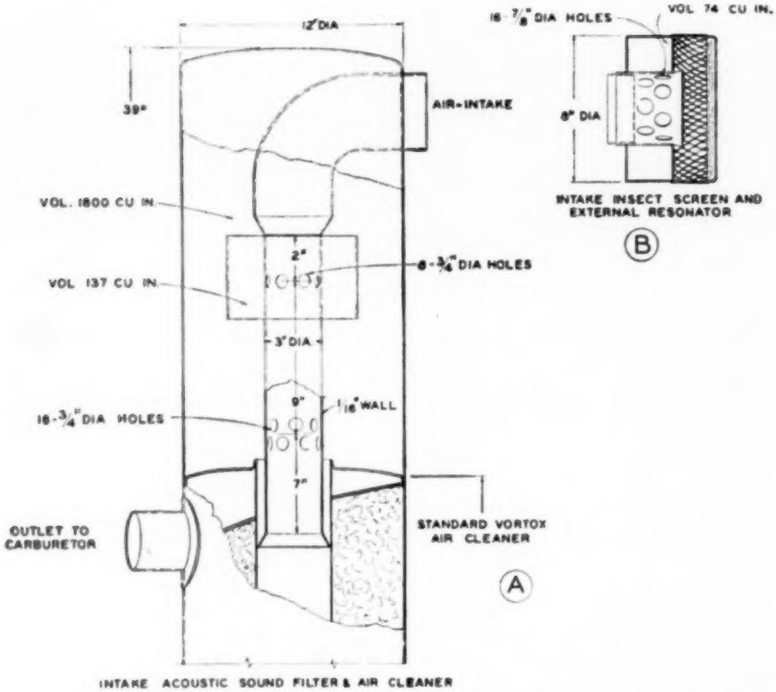

Fig. 4. (A) Basic design of carburetor air-intake acoustic filter as combined with standard Vortox air cleaner. (B) Design of external resonator and insect screen for carburetor air-intake.

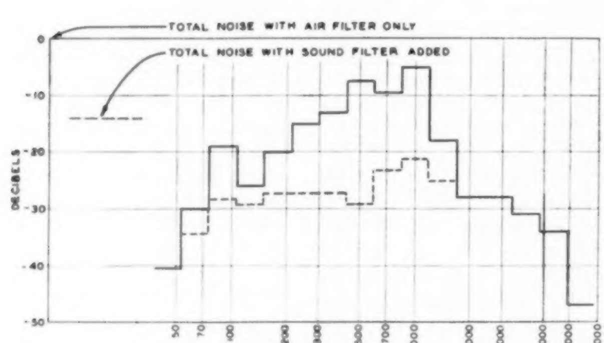

Fig. 5. Noise frequency distribution, carburetor air-intake. One-half octave band frequency analysis of source noise showing attenuation due to acoustic filter and external resonator.

major noise sources have been minimized. The usual sound attenuation is that due only to the dirt filter; therefore, an acoustical low-pass filter was designed having the configuration of Fig. 4A. It will be noted that two dissimilar volumes are used: the through pipe is smaller in cross section than the carburetor intake and the acoustic filter has been combined with the Vortox air cleaner to make one package.

The classical theory for design of acoustic low-pass filters assumes that such devices are inserted in the middle of a long pipe or conduit. In the practical case under discussion this is not true, since at one end there is a relatively short pipe, while at the other end there is the volume of the air cleaner and the acoustic resistance of the oil-saturated meshes. These discrepancies were neglected and the large single-section filter computed by the simplified formulas of Stewart,[2] rather than those more complete and complex equations of Mason.[3] One difficulty with acoustic filters concerns the terminating impedances, since an impedance match occurs only at discrete frequencies. In general, if the filter matches the con-

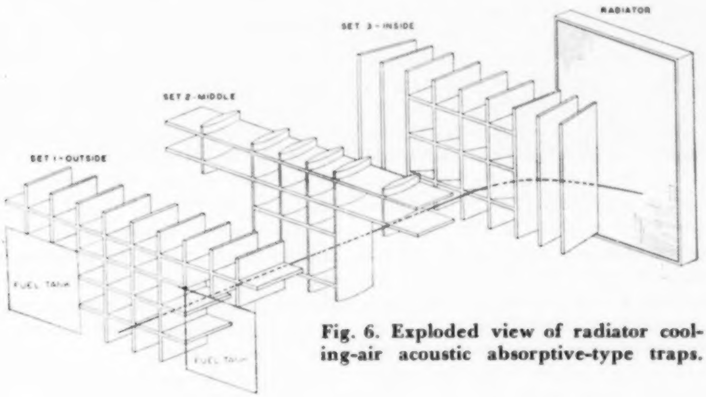

Fig. 6. Exploded view of radiator cooling-air acoustic absorptive-type traps.

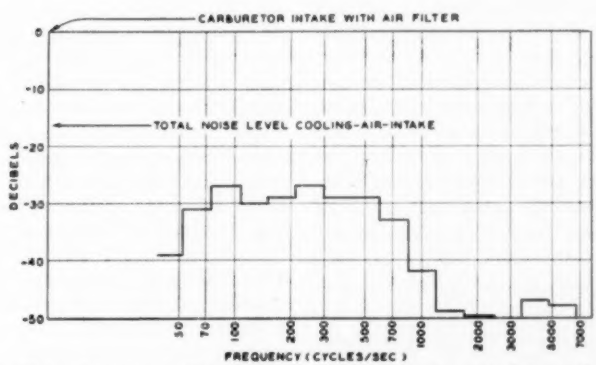

Fig. 7. Noise frequency distribution — radiator end related to carburetor intake noise with air filter only, full load. One-half octave band analysis of source noise from radiator end after installation of absorptive trap.

necting impedances at some frequency low in the passband, superior performance may be achieved. The smaller-sized pipe in the filter assists in reducing the filter impedance to improve the match, but is not of such small size as to restrict air flow.

Another difficulty with acoustic filters results from passbands above the cutoff frequency. When additional series-connected-filter sections with different cutoff frequencies, other than multiples of the preceding sections, are used, the spurious passbands are minimized. This is the reason for the section containing the second smaller volume. The cutoff frequencies of the two sections are 80 and 350 cycle/sec, respectively. Using the device as illustrated, considerable improvement obtains, although there is still a peak of transmission around 900 cycle/sec. Discrete frequency bands above 300 cycles may easily be eliminated by small Helmholtz resonators coupled to the intake pipe at the open-air end, and in this instance may be combined with the insect screen. Such a resonator is shown in Fig. 4B and the total effect of the above-described filter and resonator is shown in Fig. 5. The measurement of total noise level shows a 14-db improvement. The frequency distribution was measured in one-half octave bands from a recording made on a standard production dialogue recording channel.

In this particular application the two volumes of the filter may actually be operating as resonators coupled to the pipe, rather than as a true low-pass filter. This point needs investigation before a clear-cut understanding of the situation may be available, but in any event the configurations described have adequate performance for the requirements. The loss in horsepower due to the acoustic filter is 0.33% at sea level, full power, wide open throttle.

The principal remaining noise emanates from the radiator end and results from the large slow-speed fan and the generator. There is very little that can be done about this source without making the plant considerably larger except to absorb as much of the noise as possible. This is done, as described, by using Spraycoat and as much Dux-Sulation around the generator end-bell as possible.

All of the access methods and operating features described by Hankins and Mole have been retained in this overall design.

As described above, the plant is a complete unit of relatively low noise level which can be shipped by any common means of transportation.

Further Quieting Methods

For the great majority of motion picture locations a generating plant as described may be placed on a permanent truck or trailer, provided that, when required, it may be easily removed. When considerable long-distance hauling is to be done, a low-bed trailer is of advantage. Consequently, the described unit has been mounted on a low-bed trailer with permanently installed fuel tanks. This procedure provides space which may be used for additional silencing.

The plant was so placed on the trailer that the added space came at the radiator end. The volume from the radiator to the end of the trailer was enclosed with sheet metal, lined on the inside with 1-in. preformed glass-wool sheet. This enclosure included the fuel tanks. Three sets of straight-through vertical and horizontal partitions (commonly called egg-crates) are placed in the air stream, as shown in the exploded view of Fig. 6. Each of these is approximately 16 in. long with all surfaces covered with Dux-Sulation. The center set has the vertical partitions constructed so that a cross-sectional view of any two adjacent partitions form an air path having the approximate shape of a Venturi tube. The three sets of partitions are separated by free-air spaces of 14 in.

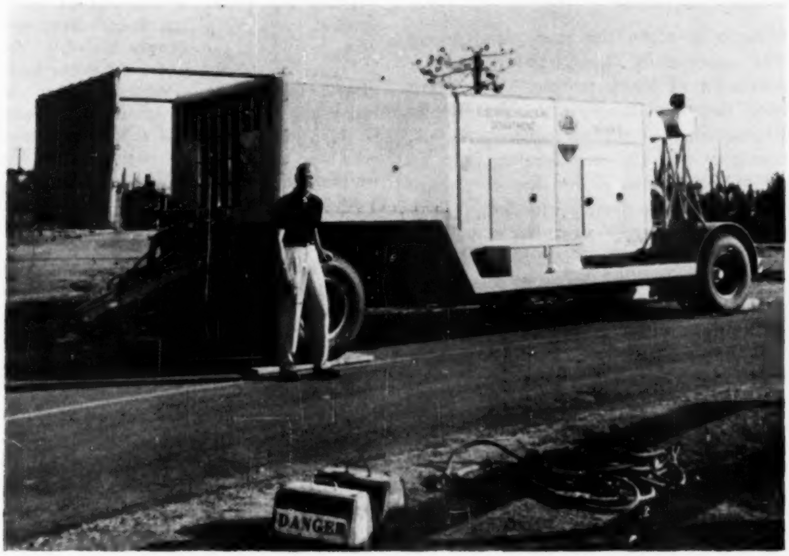

Fig. 8. Photograph of basic plant installed on trailer.

to 16 in. in length. Also, the number of vertical and horizontal members are different in each set so that if stacked one upon another the combination would appear as a set of irregular-sized openings, each being smaller than any single opening in any set of partitions. The total area of the sound-absorptive material within the traps is approximately 400 sq ft and though the air travel is essentially straight through, a reduction in noise power of 14 db is achieved. The noise spectrum is shown in Fig. 7. It is believed that considerable benefit obtains from the free-air volume between the partition sets. There has been no noticeable reduction in cooling efficiency by the application of this particular arrangement in the air path. Indeed, there is some evidence that the plant runs cooler under given conditions with this sound trap.

With the noise reductions obtained by the methods so far described, the exhaust noise became noticeable. This source is easily reduced by additional muffler capacity and in this particular case was most easily accomplished by the addition of a second muffler essentially the same as the permanently installed unit. The second muffler was also lagged with asbestos and sheet metal.

Final Plant

With all the methods and devices described, the plant appears as in Fig. 8. When necessity demands, the minimum plant is removed from the trailer and is used with some penalty in noise output requiring longer cable runs or temporary housing structures. When used complete, as shown, the plant may be used 250 ft to 750 ft from the recording set, the distance being determined by the nature of the scene and the conditions of the location. Distances of 300 ft to 400 ft are the usual placement for the average scene. The savings in cost and time on location resulting from close generator placement are obvious.

Acknowledgments

As is so often the case, this project was successfully completed with the assistance of many people. The plant itself was contracted to the Mole-Richardson Company where M. A. Hankins was of considerable help in designing the structure for the plant enclosure; Standard Auto Body Company was of great value in suggesting structure construction methods leading to good mechanical design at reasonable cost and for excellent assembly of the enclosure; the Vortox Company was very cooperative in making sample acoustic filters combined with their standard dust filter until a suitable design was found. Lastly, the project was guided by Walter Strohm and Thomas T. Moulton of Twentieth Century-Fox Film Corporation, Electrical Engineering and Sound Engineering Departments.

References

1. M. A. Hankins and P. Mole, "Designing engine-generator equipment for motion picture locations," *Jour. SMPTE, 55:* 197–212, Aug. 1950.
2. George W. Stewart and Robert Lindsay, *Acoustics*, D. Van Nostrand, New York, 1930.
3. Warren P. Mason, *Electro-Mechanical Transducers and Wave Filters*, D. Van Nostrand, New York, 1948.

Discussion

Anon: Thank you very much, Mr. Grignon. On the egg crate, was there any acoustic material?

L. D. Grignon: Yes, all the partitions are covered with a felted flameproof material ½ in. thick.

David Joy: I noticed that you showed a general lowering of the sound level and also you had the curves showing the lowering of the sound level for the individual frequencies. Why are you so interested in the individual frequencies, if you have the general sound level low; why do you have to worry about the individual frequencies?

Mr. Grignon: Equipment noise seldom has the sound energy uniformly distributed throughout the audible spectrum. By making an analysis of the noise, cycle by cycle, or in discrete bands as was done in this instance, a determination can be made of those portions of the frequency spectrum contributing the greatest energy relative to the total sound energy. In some cases the noise source can then be identified and corrections at the source applied. When it is impossible to correct the source, the greatest benefit can be obtained by assuring that the external corrective means is most effective in the frequency bands containing the largest percentage of the energy.

Harry R. Lubcke: Grig, could you estimate what proportion of the weight was added to the original weight of the engine-generator set by the sound-insulation job?

Mr. Grignon: I might make a guess at it, but I think that we can probably get a more accurate figure by asking Mr. Hankins of the Mole-Richardson Company whom I see in the audience.

M. A. Hankins: The total weight of this particular engine-generator set is 10,660 lb, including the sound-insulating housing which weighs 2440 lb. The weight of the plant less housing is, therefore, 8220 lb. Assuming that the baffling added in front of the radiator, etc., by Twentieth Century-Fox weighs approximately 800 lb, the gross weight of all the sound-insulating components is 3240 lb, which is about 35% to 40% of the basic weight of 8220 lb.

Cinecolor Multilayer Color Developing Machine

By JAMES W. KAYLOR and A. V. PESEK

The development of the various new and improved multilayer color films emphasized the need for a standard-type motion picture film developing machine that would be capable of handling any of the new types of multilayer color films. A machine of deep-tank, positive top-drive type embodying bottom elevators, turbulation or spray facilities in all tanks and practical flexibility, enabling it to be set up in any practical combination of solutions and washes to develop the various types of multilayer color films available, has been developed and put into operation as a production machine by the Cinecolor Corporation. A special arrangement of the geared drivehead allows any of the racks to be removed without affecting the drive, and the drive has been designed to provide for the attachment of desired auxiliary equipment.

When the Cinecolor Corporation began the major conversion of its facilities to the production of three-color film, it was necessary to have a developing machine for the multilayer color film which was to be used as the taking medium. At that time it was decided to try to design a standard-type machine which would be flexible enough to develop any of the color-coupling multilayer films available. Such a machine could be set up as an experimental machine to evaluate the possibilities of the various films or as a production machine to process any specific type of film and still retain flexibility to permit change-over from one system to another with a minimum of rework.

The developing machine was designed to operate at an average speed of 35 ft/min with a minimum and maximum speed of 10 to 60 ft/min. A study of the developing techniques of the several multilayer color films indicated that 32 racks, each having a capacity of approximately 100 ft or a time element of about 3 min at 35 ft/min, would be sufficient to provide for the different combinations of solution and wash times indicated for the various films. Figure 1 shows diagrammatically the general layout for several different films.

In order to provide for different combinations of solutions and washes 32 tanks are used, one for each film rack. All tanks are identical, with side

Presented on October 17, 1951, at the Society's Convention at Hollywood, Calif., by James W. Kaylor and A. V. Pesek, Cinecolor Corp., 2800 West Olive Ave., Burbank, Calif.

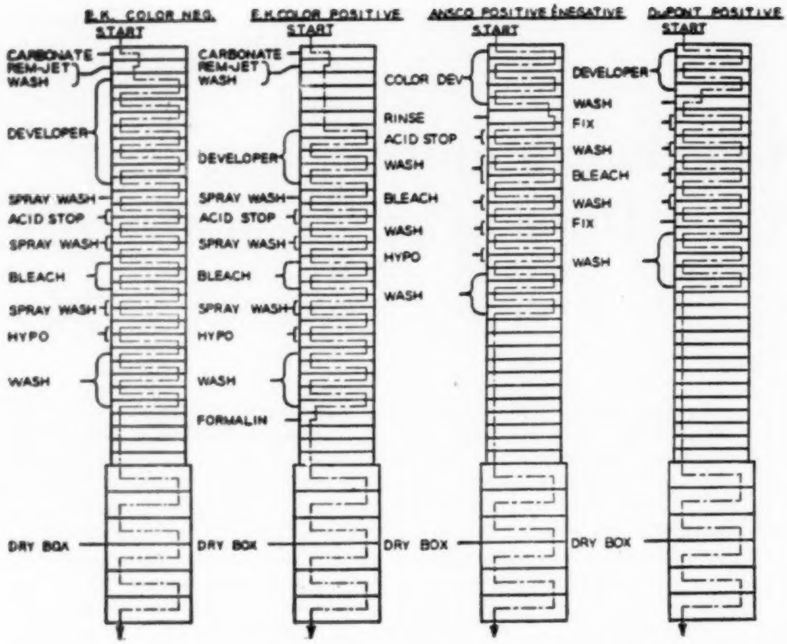

Fig. 1. Diagram of general layout for several color films.

inlets and outlets for supply, overflow and drain and with six additional fittings in each side to allow for the insertion of turbulation or spray headers, as shown in Fig. 2. On the drain side of each tank are provided two overflow fittings as well as a drain fitting at the bottom, as can be seen in Fig. 3. The additional overflow fitting is set lower than the regular overflow to provide for a submerged level control, when desired, to eliminate excessive oxidation of solutions if air is entrapped by overflow into the usual open-type return line.

The tank drive frame can be seen lowered into operating position in Fig. 4 and raised for cleaning and checking in Fig. 5. This is a tubular frame, one side of which acts as an integral gear and shaft housing for the main gear shaft that drives all of the film racks. Power is provided to the head through a right-angle gearbox from a telescoping power shaft which allows the drive frame to be run in either the raised or lowered position. The individual film roller racks are attached to the top of the tubular drive frame by two identical castings. One carries a helical gear which meshes with a similar gear within the tubular shaft housing and drives the top roller shaft through a tongue-and-key joint; the other carries a ball-bearing pin which supports the outboard or idler end of the top roller shaft. An adjustable tierod connects the two castings to maintain alignment and stiffen the whole driving head. Each casting supports two hanger rods, which in turn support the back-up roller (midway between top and bottom rollers) and the bottom roller elevator, as seen in Fig. 5. The extreme lower ends of the hanger rods are clamped

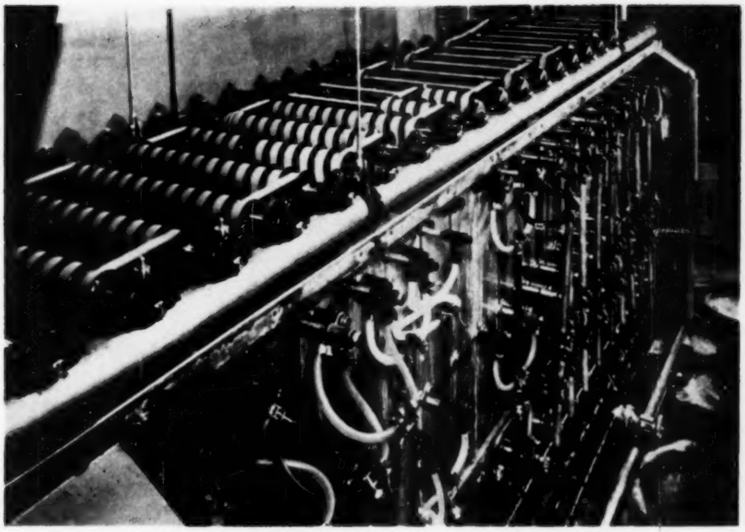

Fig. 2. Inlet side of tanks, with chemical supply lines and turbulation headers.

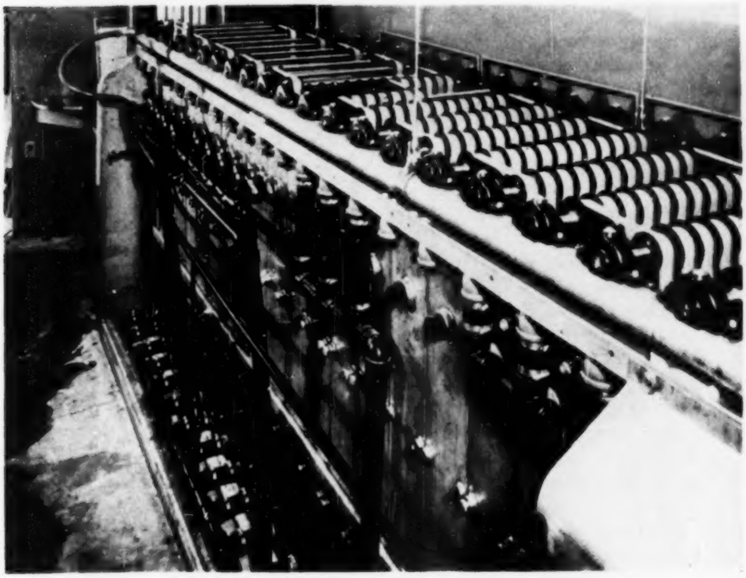

Fig. 3. Drain side of tanks.

with phenolic hangers and tied together with another tierod to insure proper spacing. The phenolic hangers also act as guides when the rack assembly is being lowered or raised in the tank.

Positive drive is applied to the film by means of a single drive sprocket setscrewed to each top roller shaft. Eleven film rollers are mounted in connection with the sprocket on a full standard rack, and are free-running on the shaft with molded, phenolic bearing inserts which also maintain correct spacing of the rollers. Additional drive is obtained, if necessary to relieve tension, by slightly spring-loading the rollers together.

The bottom roller elevator consists simply of two phenolic hangers, each clamped to two short lengths of stainless-steel tubing that ride up and down on the two hanger rods on each side. The lower shaft is slipped into holes in the hangers and centered by setscrew collars at each end. The whole assembly is tied together by a separator assembly which also keeps the film strands properly aligned with the bottom rollers. These are free-running on their shaft and spaced by molded, phenolic bearing inserts, the entire weight of the bottom elevator assembly being supported by the film strands.

The complete drivehead can be raised or lowered by six stainless-steel cables connected to an electrical hoist. The cables are conveniently spaced three to a side, as shown in Fig. 4, and are adjustable with turnbuckles to equalize tension and insure a straight and even lift. The hoist is provided with an electrically operated brake which minimizes coasting and holds the head in any position desired. Two limit switches are mounted on the ceiling, one at each end of the head to prevent it from being raised too far.

Film is fed into the machine from a clutch spindle mounted on a feed table. The film passes first over a feed elevator of approximately 100-ft capacity which allows about 3 min for splicing on new rolls. After passing through the tank section, the film moves through an air blowoff or squeegee and into the dry box. The blowoff unit is hinged so that it can be tipped down out of the way when the drivehead is to be raised to the ceiling. Air is supplied to the blowoff from a Nash waterseal compressor at about 2 to 3 psi, through a manifold which is also extended the length of the tank section with outlets at the center and feed end for connection to various auxiliary equipment.

The dry box, shown in Fig. 6, is of sheet-aluminum construction with three sliding glass doors on each side. The drive is a positive top drive, similar in construction to the tank drive, and consists of a tubular frame with the drive gear shaft and castings previously described, but mounted inverted, with the castings on the bottom, on four corner supports. The drive has six banks of rollers or film racks, the lower rollers being ball-bearing and mounted on elevators. Centered between the top and bottom rollers on each rack there is a back-wiping roller to remove any drops or streaks from the base side of the film as well as to keep the film strands separated. The dry box holds approximately 900 ft of film giving about 27 min drying time at 35 ft/min. Air is supplied to the dry box under controlled temperature and humidity conditions from a heating and blower unit. Temperature and humidity are provided by a steam supply and are regulated by Minneapolis-Honeywell controllers.

The dried film is taken up as it leaves the dry box on either of two power-driven, friction-clutch take-ups (two are provided for rapid change-over) which are shown in Fig. 6. Power for the take-ups is supplied from a separate gear-head motor of sufficient output speed to drive the take-ups at the maximum speed of 60 ft/min.

The machine speed controls and speed indicator are mounted on a panel be-

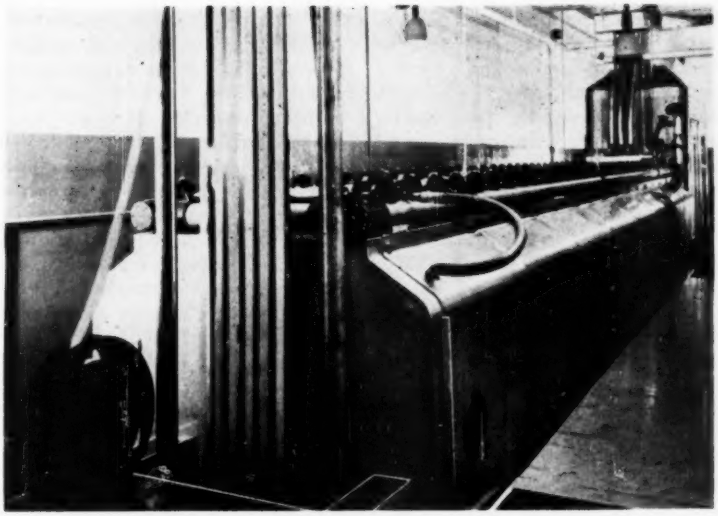

Fig. 4. Tank section of machine with drivehead in operating position.

Fig. 5. Drivehead raised for maintenance or thread-up.

tween the tank section and the dry box cabinet. Speed of the machine is governed by a speedranger, located below the floor, which is adjusted with a chain drive from the speed-control knob on the panel. Also on the panel is one of three stop-start stations, the other two being mounted on the feed table and take-up table, respectively.

Water is supplied to the various wash tanks through a common header. Deep wash tanks are fed through the bottom inlet and overflowed into the open drain at the top of the tank. Spray wash tanks are fed directly through the six spray headers inserted through the sides of the tank, and drained through the bottom drain.

The chemical solutions are supplied to the proper tanks from storage tanks located in the basement through Saran piping and headers. Solution return is effected by gravity flow from overflows to the storage tanks. Individual pumps are employed for each solution, and flow is metered through Schutte-Koerting Rotameters. Submerged drains are provided on the developer tanks and the level is controlled by means of wet-type liquid level switches actuating solenoid valves on the lower end of the drain lines.

Turbulation of the chemical solutions is accomplished where desired by withdrawing the solution from the machine tanks through the bottom drains and pumping it back through the spray headers. The turbulation flow is also metered through Rotameters.

Temperature control of the solutions is maintained by passing either hot or cold water through stainless-steel, heat-exchange coils installed in the solution storage tanks. However, the problem is primarily one of cooling the solutions, so Taylor Temperature Recording Controllers are used to regulate the chilled water supply to each coil, hot water being used only to warm the solutions after shutdowns during cold weather, when occasionally the solution temperature drops below the required point. A portion of the basement section can be seen in Fig. 7, showing tanks, temperature controllers, flowmeters, and solution supply and turbulation pumps.

The machine described in this paper has been operated very satisfactorily as a production machine for over twelve months. Considerable interest in it has been shown in the industry. A second unit, similar to the first, is now being readied to increase the capacity of color-coupling multilayer film processing by the Cinecolor Corporation.

Acknowledgment: We wish to acknowledge with thanks the helpful cooperation of R. W. Lorenzen, O. W. Murray, J. K. Stewart, E. W. Rutherford and the many others who contributed to the design and development of the Cinecolor Multilayer Color Developing Machine.

Discussion

John G. Stott: Did I understand that you turbulate your bleach solution? Could I ask why?

James W. Kaylor: It was recommended, more or less, in the instructions for the technique of developing the EK color film that we use at the present time.

Mr. Stott: Well, the usual use to which turbulation is put, is in a stage of chemical processing, where the process doesn't actually go to completion, but where you want to make all the film go to the same point at the same time. In other words, you want all the film to be processed uniformly, but the fixing operations and the bleaching operation are usually considered as going to completion, so that turbulation is, as I see, of absolutely no use.

Mr. Kaylor: Well, I can say that we have tried it both ways, with turbulation and without, and it was decided to use the turbulation method. I believe that that question probably could be answered a little more fully in the paper that Mr. E. W. Hart is going to read tomorrow night, I believe, describing our three-color

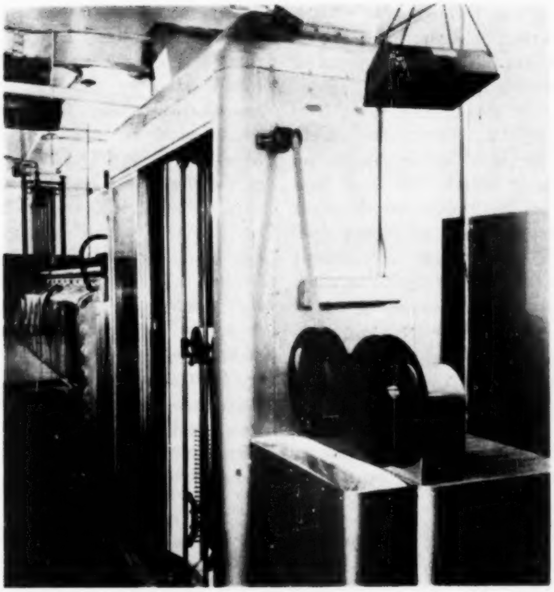

Fig. 6. Dry box and take-ups.

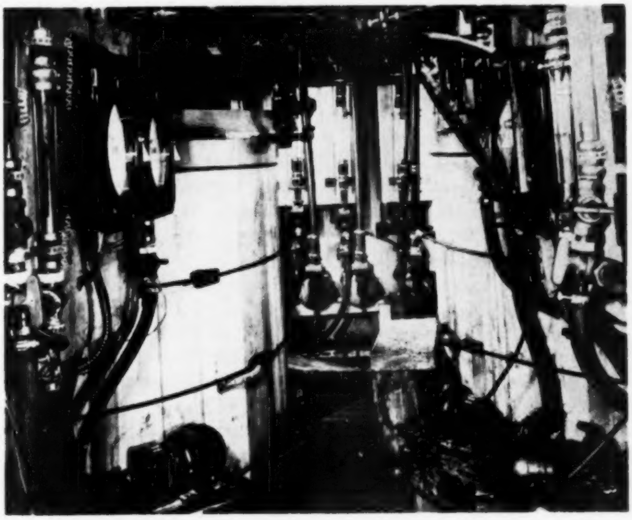

Fig. 7. Section of basement showing storage tanks, temperature controls, chemical pumps and flowmeters.

process, also going through the various steps of the developing of our EK negative.

Mr. Stott: What is the total amount of film in the developer section?

Mr. Kaylor: At the present time, it is pretty close to 3000 ft. I say at the present time because the machine can be set up to take a total of about 3200 ft of film, but in some of the tanks we do short strand because we need much less than three minutes' developing time, three minutes', let's say, chemical time in those particular tanks; in fact, in one or two of the tanks we have only a couple of feet of film.

Mr. Stott: Are your bottom rollers floating rollers?

Mr. Kaylor: Yes, they're floating rollers. The bottom rollers are all mounted on elevators, with one exception where we have them fixed to maintain a certain amount of tension. I might say, perhaps, that in this auxiliary equipment that was mentioned — in the EK machine, for example — it was found necessary to install what we call a rem-jet remover roller, to take off the jet-black backing of the film. We had to install a velvet-covered roller midway down into a tank and use that to buff off the anti-halation backing.

Edward H. Reichard: In the pictures of the machine, I noticed that your top rollers in the developing section are out of the solution. Is that right?

Mr. Kaylor: No. Perhaps I should have explained that in our developer section we actually use submerged drives — the nine shafts there are submergible beneath the solution level.

New Magnetic-Recording Head

By MARVIN CAMRAS

A three-pole magnetic head produces a magnetic field at the recording gap which is more uniform throughout the thickness of the magnetizable layer, and decays more rapidly at the trailing edge. With this head, optimum bias is practically the same for high as for low audiofrequencies. High audiofrequencies are recorded at a 3-db to 7-db higher output level before distortion as compared with a similar head of conventional design.

Two important factors have made possible the present-day low magnetic-recorder speeds: (1) thin, uniform recording tapes with high magnetic properties; and (2) efficient magnetic heads with very short gaps.

Effect of Short Gaps

Efficiency and short gaps do not go together, unfortunately, because, as the gap is shortened, more of the useful flux tends to be lost across the pole faces. The situation for a playback head is shown in Fig. 1. A recorded signal such as A produces a certain external flux which is utilized more or less efficiently to thread a voice coil. At the pickup gap some of the flux from the record follows path B through the core and through the voice coil. But other lines of flux such as C and D prefer to take the short path across the faces of the pickup gap. Still others, such as E, complete their circuit through the air or backing material on the side opposite the gap.

The flux divides inversely according to the reluctance of each path. A gap measured in tenths of a thousandth of an inch may have less reluctance than an inch or two of high-permeability core material. Consequently, it may waste a major portion of the playback flux.

When we use such a short gap for recording as in Fig. 2, we find that practically all of the flux concentrates in the easy path across the short gap, and a much lower field acts on the record material, especially on the side away from the gap.[1] As we increase input to the head to produce an adequate recording field, we find that the head core approaches saturation, and in many cases we cannot reach optimum recording conditions regardless of how much input we feed into the voice coil.

A third problem of magnetic heads, that of maintaining good contact with the record, becomes much more important as the gap is decreased. Studies show that even with ordinary heads,

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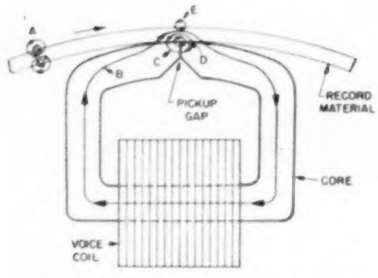


Fig. 1. Flux paths in a magnetic head on playback.

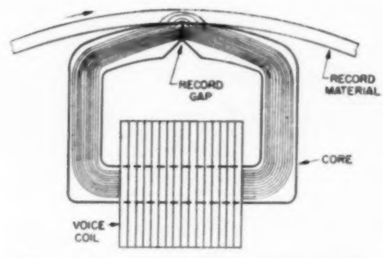
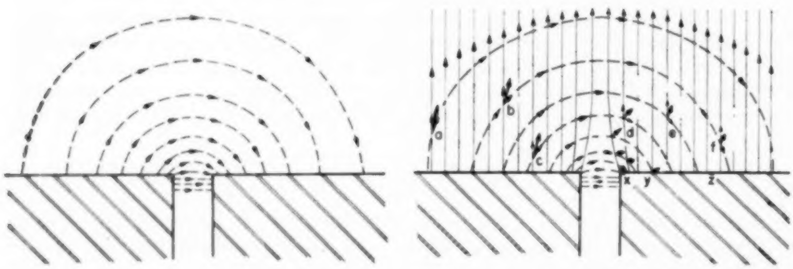


Fig. 2. Flux paths in a magnetic head during recording.



A. Magnetic field produced by gap. **B. Superposed cross field adds vectorially to the gap field.**

Fig. 3. Flux paths of an X-field head.

a separation of only 0.0001 in. causes marked fall-off in high-frequency response.[3] With shorter gaps, a 0.0001-in. spacing would be fatal. Thus, a decrease in record or playback gap, by itself, does not solve the problem of obtaining better resolution.

The Cross-Field Head

With a conventional head the magnetic field at the recording gap is as shown in Fig. 3A. As an approximation, it has a semicircular direction with respect to the gap center and decreases inversely with the distance. Ordinarily we have little control of the shape of this field. Suppose we now provide a vertical field as in Fig. 3B and combine this field with the semicircular field of the gap. (The additional field is termed a *cross field* or *X-field*, and a head which provides such a field is called an *X-field head.*) Vector addition of the components, as, for example, a, b, c, d, e and f in Fig. 3B, gives some interesting results:

1. On the left-hand side of the gap, the components are additive, and the resulting field is stronger and more nearly vertical than the gap field alone.
2. On the right-hand side of the gap, the vertical components oppose each other, and can be adjusted to cancel at some point near the right-hand edge of the gap. For example, in Fig. 3B near the surface of the right-hand pole, at x, the gap field predominates; while at z the cross field is stronger. Somewhere in between, near y, cancellation occurs, leaving a minimum field. This means that we have a steep gradient of field in the region of x.

The resultant field is mapped in Fig. 4. A head which produces such a field has certain advantages over conventional heads for magnetic recording:

1. The field falls off more sharply as the record leaves the gap. This improves the resolution and minimizes "recording demagnetization."[3]

2. In a direction away from the pole pieces, the field changes less rapidly, giving more uniform magnetization through the thickness of the record, and less variation due to poor contact between head and record.

3. The field at the right-hand pole edge is more nearly longitudinal.

4. The main recording head operates at lower flux density.

5. The shape of the resultant field can be controlled by varying its components.

Figure 5 is a photograph of an early X-field head with taps to allow adjusting the relative number of turns on each of the legs. The auxiliary pole piece overhangs the head proper and is spaced about 15 mils above it, which gives clearance for threading and for splices in a 2-mil tape. Figure 6 shows typical connections for this head.

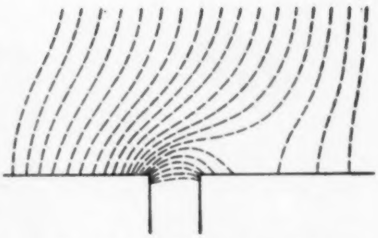


Fig. 4. Resultant of gap field and X-field.

Test Results

To measure the improvement resulting from the cross field, the head was first tried with the center coil disconnected, so that it functioned as an ordinary head. Output vs. input curves were then run at 10,000 cycles, using the bias at which maximum possible undistorted output level occurred. Then the cross-field coil was connected, and adjustment was again made for maximum undistorted 10,000-cycle output. The results are given in Fig. 7, and indicate a $4\frac{1}{2}$-db advantage for the X-field connection, which means that about 65% more flux can be recorded at the high frequency on the same tape.

It is well known that when supersonic bias is increased beyond a certain rather critical value, the high-frequency response of a recording system goes down rapidly. The best explanation for this effect is that partial erasing of the short wavelengths occurs in the extended field of the recording gap (see "recording demagnetization"[3]). On the other hand, for distortionless low-frequency recording, we need enough bias to excite the recording layer through its entire thickness, and this turns out to be considerably more than for optimum high-frequency response. The result is usually a compromise in which the high frequencies suffer.

Bias requirements of the new head were determined both with the conventional and with the X-field connections. Results are shown in Table I.

Table I.

Connection	Bias required for undistorted 100-cycle output	Bias for max. 10-kc output	Loss at 10 kc due to increased bias
Standard	1000 ma	600 ma	7 db
X-field	650 ma	560 ma	0 db
X-field	(Purposely overbiased to 1000 ma)		1.5 db

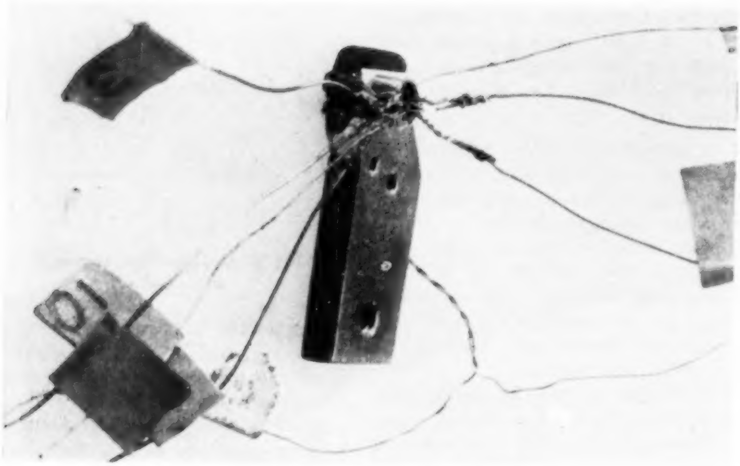


Fig. 5. Experimental X-field head.

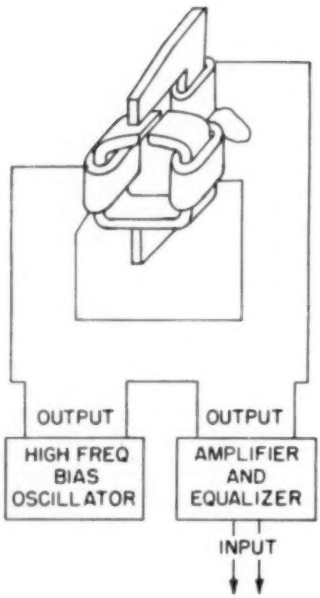


Fig. 6. Typical connections for X-field head.

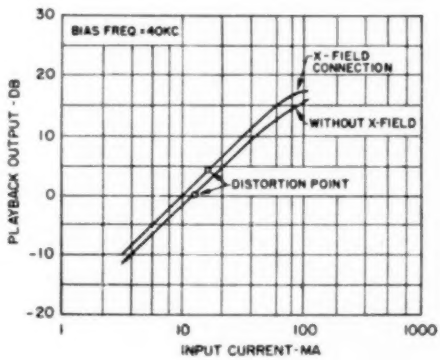


Fig. 7. Output-input curves for head at 10 kc.

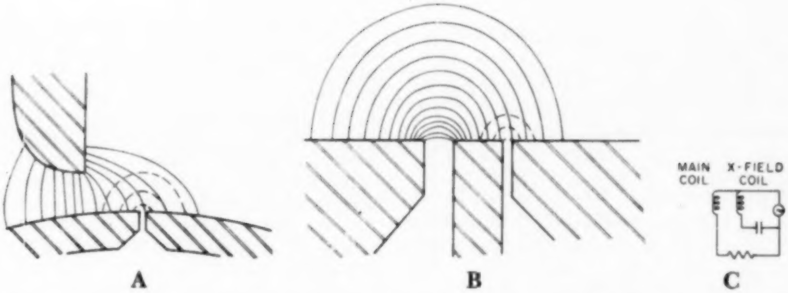


Fig. 8. Modified X-field head designs: (A) Effect of moving X-field pole piece to the left; (B) Double gap X-field head; and (C) Circuit for producing a rotating field at recording gap.

We note that bias requirements for the X-field head are practically the same for the high and low frequencies, and overbiasing has little effect. If the tests of Fig. 7 are conducted on a practical basis of optimum bias for low frequencies in each case, rather than bias for maximum 10-kc output, the advantage of the X-field head is even greater.

Variations

Some variations in the X-field head are shown in Fig. 8. In Fig. 8A the overhanging pole piece has been moved to the left. This tilts the cross field from the vertical direction and causes better cancellation of the gap field at the trailing edge. Also, the cross field decreases in intensity as we move to the right, so that it has less effect on the record beyond the cancellation point. The intense vertical field at the left of the record gap can be used for erasing, and its intensity may be increased still further by sharpening the pole piece. Or if we run the tape backward and make appropriate adjustments, this head becomes an efficient vertical recording head.

Figure 8B shows a head that has advantages of the previous one, but dispenses with the overhanging pole piece. Two gaps on the same side of the recording head are spaced closely enough together so that the right-hand part of the field produced by the large gap acts as a cross field for the small recording gap. The large gap may be used for erasing. In this connection, we found that by using audio in the main field only, but retaining the X-field principle for bias, excellent performance was obtained with this very simple design of erase-record head.

Figure 8C is a circuit which shows the degree of control possible with the X-field head. Here we use a condenser of relatively high reactance in circuit with the X-field coil to give a current 90° ahead of the voltage. A resistor in the recording coil circuit gives a current in phase with the voltage. The result is a head which provides a rotating bias field. Similarly, we can produce a rotary signal field or even a rotary erasing field.

We have found that although the primary advantages of the X-field head are in recording, there are also advantages in playback, since a reciprocal magnetic relation holds.

Conclusions

The field of a recording head gap can be modified to advantage by combining it with a cross field.

An X-field head has better resolution,

and a more ideal bias adjustment than an ordinary head.

Modified designs of X-field heads are as simple to manufacture and to use as conventional heads.

References

1. S. J. Begun, "Magnetic field distribution of a ring recording head," *Audio Eng., 32:* 11–13, 39, Dec. 1948.
2. R. Herr, B. F. Murphey and W. W. Wetzel, "Some distinctive properties of magnetic-recording media," *Jour. SMPE, 52:* 77–87, Jan. 1949.
3. O. W. Muckenhirn, "Recording demagnetization in magnetic tape recording," *Proc. IRE, 39:* 891–897, Aug. 1951.

Discussion

Anon: Can you tell us what the channel width was about?

Marvin Camras: This was done with an eighth-inch wide channel on quarter-inch tape.

Anon: Would the same results be obtained with 35mm magnetic film?

Mr. Camras: I don't see why the medium would affect the result. I think it would be substantially the same.

Anon: Do you still find the same variations in output of low frequency with this new type of head as you do with the normal-type head; the change of amplitude with frequency at about 100 cycles?

Mr. Camras: You mean the bumps in the response curves? As I remember, I don't think it had very much effect on that. That's caused by something else.

Anon: I know, but the changing of the contour of the field might affect that. As a matter of fact some of those bumps are likely playback effect, and if you use conventional playback heads it wouldn't change.

M. G. Townsley: When you use a cross-field head for record, you improve resolution on the film and the improved results are on the film. You said something very briefly about using a cross-field head for playback. What type of a cross field do you put on the head when you are using it as a playback head?

Mr. Camras: Of course, in a playback head you are just picking up fields, using it as a sensitive element for picking up something that's recorded. By using it for playback I meant that we used the cross-field coil and left it connected in the circuit during playback. We haven't run exhaustive tests and I haven't shown any results here of what it can do, but it seems to give us advantages in playback.

Mr. Townsley: In other words you make a fairly large gain. Suppose you use a head like this as a combined record playback head, you'd make a fairly large gain in record and a small further gain in playback?

Mr. Camras: Yes, I would say that. You're utilizing the material throughout the thickness of the layer to better advantage than you are with the conventional head that operates on one side of the record.

Mr. Townsley: The cross field so to speak is induced by the tape material itself as it passes over the head if you've got a double gap, for example, as you showed in the last picture.

Mr. Camras: I don't think I understand.

Mr. Townsley: I don't either.

Mr. Camras: Those gaps incidentally are very close together, just a few mils apart; and in that case you might get additional reinforcement or pickup of low frequencies with your second gap. If you try to work such a scheme with conventional double-gap heads where the record gap may be spaced a hundred mils or more from the erase gap you'd get bad echo effects, of course.

Mr. Townsley: It would seem to me that you might, with the gap space closer together, get some interference cancellation effects at fairly high frequencies, because of the phasing.

Mr. Camras: I haven't noticed those things. One gap is considerably larger than the other, at least ten times as large.

Push-Pull Direct-Positive Recording—An Auxiliary to Magnetic Recording

By LESLIE I. CAREY and FRANK MORAN

This paper explains the transferring of magnetic film from the daily okayed production takes to push-pull direct-positive film. By using a protective coating on the sound track, the cutting-room hazards are reduced 90%. This coating can be "peeled off" just before dubbing, assuring a new clean track from which to dub.

THE ADVANTAGES of using direct-positive records as a part of a magnetic recording program have been previously described by Loren L. Ryder in the JOURNAL.[1] The records mentioned by Mr. Ryder are of the variable-density direct-positive type, utilizing the supersonic bias previously described.[2] The purpose of this paper is to describe the use of variable-area double-width push-pull records as an adjunct to the magnetic-recording program now in use at Universal Studios.

The difficulties involved in editing magnetic film and the expense involved in cutting it for dubbing purposes suggested the need of a medium which is inexpensive and, at the same time, capable of giving quality comparable to that obtained from magnetic films. In the opinion of the authors, the 200-mil variable-area double-width push-pull track adequately fulfills these requirements. The double-width track was selected because of its advantage over a single track, from a signal-to-noise standpoint, and the push-pull feature, as described below, was selected because of the lack of critical processing problems and improved signal-to-noise ratio. Direct-positive was selected because it eliminates the need for a negative record with its accompanying processing expense and printing losses.

Presented on May 4, 1951, at the Society's Convention in New York, by Leslie I. Carey and Frank Moran, Universal-International Pictures, Universal City, Calif.

The underlying principles involved in making a direct-positive record with the light valve have been described in the JOURNAL.[3] The double-width push-pull variable-area track is obtained by applying a signal to the center ribbon and noise reduction to the two outside ribbons of a three-ribbon variable-area light valve.[4]

In order to obtain the type of track under discussion, a standard Western Electric RA-1231 Type Recorder,[5] equipped to record either a single- or double-width variable-area negative track, was modified to incorporate the direct-positive feature. No major changes were made in the film-pulling mechanism of this recorder, with the exception that facilities were provided so that the recorder could be run either in the normal forward or in a reverse

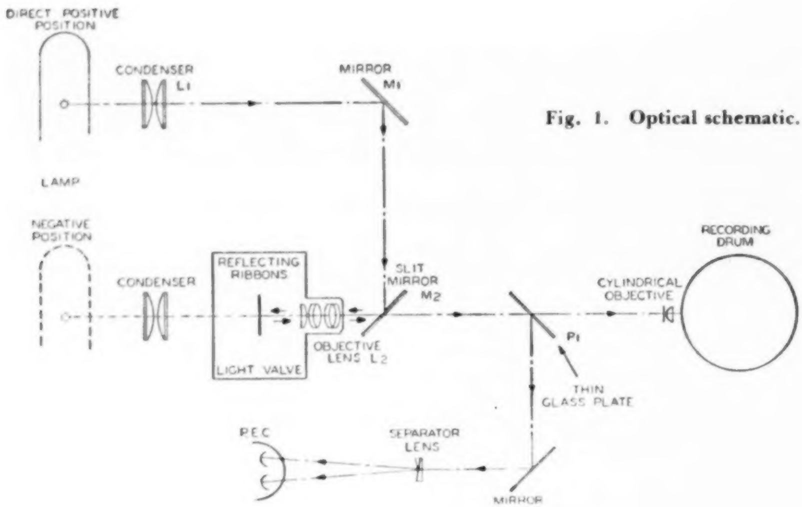


Fig. 1. Optical schematic.

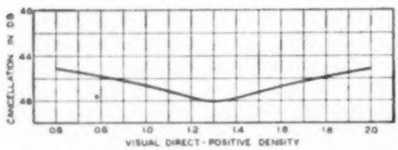


Fig. 2. Cross modulation characteristic.

direction. This permitted the recording of the normal negative track in the regular forward position, and the direct-positive track by the simple process of reversing the direction of the film during recording to eliminate the necessity of changing the position of the light valve. The studio has found it convenient to use a synchronous motor with the recorder on all occasions except for dubbing when, of course, the interlock motor is essential. In order to make both these drive facilities readily available, the recorder was equipped with two drive motors — one synchronous and one interlock — coupled through a single shaft to the drive mechanism. Either motor could then be selected by a simple switching arrangement.

The changes incorporated in the optical system to obtain the direct-positive type of track are noted below.

The Western Electric RA-1247 Three-Ribbon Light Valve[4] was restrung with reflecting surface ribbons. The optical system of the modulator was modified, as shown schematically in Fig. 1, so that the direct-positive type of record is obtained with the light source in the upper position. In this position the light passes through the condensing lens, L1, to a mirror, M1, where it is deflected downward to the slit mirror, M2. The latter directs the light through the objective lens, L2, in the light valve onto the reflecting ribbons. The light reflected by the ribbons is returned through the slit in the slit mirror, thence through a clear-glass plate, P1, and through the objective lens to the film. The clear-glass plate reflects a small percentage of the recording beam back to the photocell for PEC monitoring.

The double-width push-pull track offers two distinct advantages over the standard track, first, by virtue of the extra width, an improvement in the signal-to-noise ratio and, second, the push-pull feature offers low and rela-

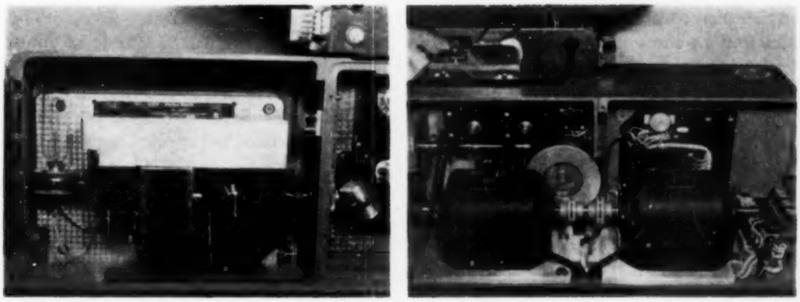


Fig. 3. Direct-positive recorder. Left: rear view. Right: front view.

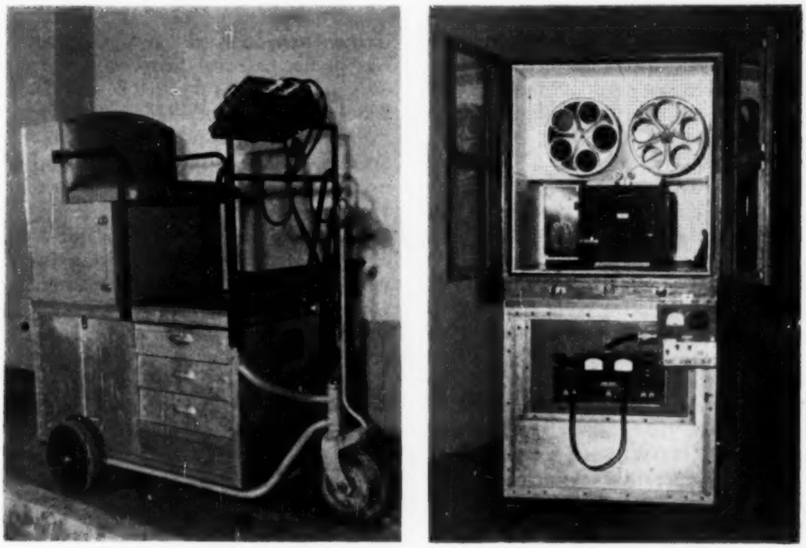


Fig. 4. Magnetic channel. Left: front view. Right: rear view.

tively constant cross-modulation products over a large range of densities (Fig. 2). The latter feature greatly simplifies the processing problems which are normally encountered on tracks which do not have the push-pull feature. For example, a track density of 1.8 on Eastman Kodak Emulsion 5372 was found to be completely feasible. When this is compared to a "balance" density around 1.3 for a single track on the same emulsion, the advantages of increased signal output and reduced grain noise are immediately evident.

The 200-mil push-pull variable-area method of recording was put into service at Universal Studios on January 10, 1951, on the production *The Iron Man*, and subsequently on a musical short, *Ziggy Elman and His Orchestra*. It is currently being used on the production *Fiddlers Green*. All original takes are being made

on 35mm sprocket-hole-type magnetic film and at the end of a day's work all "print" takes are transferred to direct-positive. In this way the magnetic film becomes the "negative" and is stored intact until the picture is released, at which time it will be erased and available for future productions. The direct-positive track now serves as the "daily" sound track and eventually, after editing and cutting, as working and dubbing prints.

The quality of sound obtained through the magnetic-direct-positive procedure is noticeably superior to and more dependable than that obtained with the regular photographic process. A careful check has indicated that very little noise is introduced as a result of running for the "dailies" and during handling in the cutting process.

Not only does the use of magnetic-direct-positive system improve the overall sound quality of a production, but economies in the cost of film and film processing are realized at the same time. While exact figures are not yet available, approximate relative costs between the regular photographic process and the magnetic-direct-positive process have been estimated on *The Iron Man* production. A total of 104,000 ft of recording was made on this production. Actually 52,000 ft of magnetic film were used with separate tracks at either edge of the 35mm film. One half, or 29,000 ft, of this recording represented "print" takes which were transferred to direct-positive. If this production had been originally recorded on a photographic negative, from which working prints were to be made, a total of 104,000 ft of negative stock, plus 29,000 ft of positive stock, plus the negative and positive processing cost would have involved an expense of approximately $4100. As the production was actually recorded first on magnetic film and then with the "print" takes transferred to direct-positive, 29,000 ft of direct-positive stock plus its processing involved a cost of approximately $884. The initial investment in 52,000 ft of magnetic film is approximately $2080. However, inasmuch as this film can again be used after erasure, only a portion of the cost should be applied against this production.

Sufficient time has not yet elapsed to make a sound determination of the life of the magnetic film, inasmuch as some of the stock obtained at the beginning of our magnetic program three years ago, and used frequently since that time, is still in good condition. If it is assumed conservatively that the stock can be used 25 times, the cost per production is then approximately $84. The total cost of the film together with the processing of the direct-positive is, therefore, $884 plus a prorated cost of $84 for the magnetic film, or a total of $968, as against $4100 for the negative-positive method, or a saving of approximately $3132 per production.

The use of the push-pull variable-area direct-positive recording as an adjunct to the magnetic recording program at Universal Studios has proven to be completely successful from the standpoint of simplifying and cutting the cost of the recording operations, as well as retaining the high quality of the original magnetic recordings.

References

1. Loren L. Ryder, "Motion picture studio use of magnetic recording," *Jour. SMPTE, 55:* 605–612, Dec. 1950.
2. C. R. Keith and V. Pagliarulo, "Direct-positive variable-density recording with the light valve," *Jour. SMPE, 52:* 690–698, June 1949.
3. Lewis B. Browder, "Direct-positive variable-area recording with the light valve," *Jour. SMPE, 53:* 149–158, Aug. 1949.
4. John G. Frayne, "Variable-area recording with the light valve," *Jour. SMPE, 51:* 501–520, Nov. 1948.
5. G. R. Crane and H. A. Manley, "A simplified all-purpose film recording machine," *Jour. SMPE, 46:* 465–474, June 1946.

Proposed Standard Enlargement Ratio for 16Mm to 35Mm Optical Printing

EFFORTS TO reduce costs in color cinematography have led, in the past few years, to an appreciably increased commercial use of 16mm film as original negative for 35mm release prints. Optical enlargement printing is, of course, an essential factor in this process. A standard magnification ratio thus becomes a necessity since the difference in aspect ratios of the two film sizes precludes the simple use of the 35/16 ratio.

The Laboratory Practice Committee, chaired by John Stott, tackled the problem in February 1951; a first draft was submitted by Gordon Chambers in May 1951 and approved by the Committee a few months later. A revised draft was subsequently approved for publication by the Standards Committee and is published on the following page for a 90-day period of trial and criticism.

Please forward any comments, in duplicate, to Henry Kogel, Staff Engineer, at Society headquarters, by April 15, 1952.

Proposed American Standard Enlargement Ratio for 16Mm to 35Mm Optical Printing	PH22.92

In the enlargement printing of 16mm film to 35mm film, a magnification of 2.21 ± 0.01 shall be employed and the center of the 16mm frame as enlarged shall coincide with the center of the 35mm aperture in the enlarging printer.

This will mean a scanned area on the 16mm frame of 0.272 inch ± 0.002 × 0.373 inch ± 0.002 will be projected through the 35mm projector aperture when the print is used in the theater. This corresponds to a frame of 0.284 inch × 0.380 inch if the 16mm original were projected directly.

The scanned area of the 16mm frame in the printer as enlarged to the 35mm camera aperture is 0.286 inch ± 0.002 × 0.393 inch ± 0.002.

Attention of camera users is invited to the desirability of using a camera finder matte 0.272 inch ± 0.002 × 0.373 inch ± 0.002 when exposing 16mm film to be enlarged to 35mm film.

Note: In enlargement from 16mm positive or reversal original to 35mm negative a black frame line will result on the final 35mm print. In the case of enlargement from 16mm negative directly to 35mm print, white frame lines will result. If the height of the 16mm aperture for enlargement from 16mm negative to 35mm print is made 0.300 inch, the resulting aperture image on the 35mm print will be from 0.660 to 0.666 inch in height. While the frame line will not be entirely black, there would be a black margin on either side of the image which would give an additional safety factor in projection.

NOT APPROVED

71st Semiannual Convention

The Spring Convention has for many weeks been in the minds and work of those generally responsible for conventions and of those especially responsible for the Chicago Convention, April 21–25, at The Drake.

Bill Kunzmann has already spent a good deal of time in Chicago and has done all the groundwork of planning with The Drake and also already has a roster of chairmen for the dozen major activities and functions throughout the convention. The complete roster will be published in the February *Journal*.

John Frayne, at an editorial meeting during the Hollywood Convention, appointed as Program Cochairmen **R. T. Van Niman** and **George Colburn.** They and others are already at work on the papers program under direction of Papers Committee Chairman **Ed Seeley.** Manuscripts and suggestions should go promptly to any of the Papers Committee, listed below; but all manuscripts and authors' forms (these are available from members of the Committee or from Society headquarters) should reach Cochairman George Colburn, 164 N. Wacker Drive, Chicago 6, Ill., as soon as possible.

John Frayne also confirmed at the Hollywood editorial meeting the choice of **Richard O. Painter** to be Vice-Chairman for High-Speed Photography for Chicago. In addition to the planning of at least two high-speed photography sessions, the editorial meeting and subsequent planning have evolved the following tentative schedule of session subjects: two sessions on 16mm; one on sound recording; three or four sessions on television; one on laboratory problems; and one general session.

C. E. Heppberger, Secretary-Treasurer of the Central Section, has the very important duties of Local Arrangements Chairman. He put out a solid two-page memo in late November to begin tying together the long roster of all the arrangements he must be sure about.

PAPERS COMMITTEE

Chairman: **Edward S. Seeley,** Altec Service, 161 Sixth Ave., New York 13

71st Convention Program Cochairmen: **R. T. Van Niman** and **George W. Colburn.** *Address manuscripts and authors' forms to George Colburn, 164 N. Wacker Drive, Chicago 6, Ill.*

Vice-Chairmen

For New York: **W. H. Rivers,** Eastman Kodak Co., 342 Madison Ave., New York 17

For Washington: **J. E. Aiken,** 116 N. Galveston St., Arlington, Va.

For Los Angeles: **F. G. Albin,** Station KECA-TV, American Broadcasting Company Television Center, Hollywood 27, Calif.

For Canada: **G. G. Graham,** National Film Board of Canada, John St., Ottawa, Canada

For High-Speed Photography for Chicago: **Richard O. Painter,** General Motors, Proving Ground Section, Milford, Mich.

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Dudley Goodale, National Broadcasting Co., 30 Rockefeller Plaza, New York 20.

Charles Handley, National Carbon Div., 841 E. Fourth Pl., Los Angeles 13, Calif.

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Scott Helt, Allen B. Du Mont Labs., Inc., 2 Main Ave., Passaic, N.J.

C. E. Heppberger, National Carbon Div., 230 N. Michigan Ave., Chicago 1, Ill.

J. K. Hilliard, Altec Lansing Corp., 1161 N. Vine St., Hollywood 38, Calif.

L. Hughes, Hughes Sound Films, 21 S. Downing St., Denver, Colo.

P. A. Jacobson, University of Washington, Seattle, Wash.

William Kelley, Motion Picture Research Council, 1421 N. Western Ave., Hollywood 27, Calif.

E. P. Kennedy, Signal Corps Labs, Fort Monmouth, N.J.

George Lewin, Signal Corps Photographic Center 35-11 35 St., Long Island City 1, N.Y.

E. C. Manderfeld, Mitchell Camera Corp., 666 W. Harvard St., Glendale 4, Calif.

Glenn Matthews, Research Laboratory, Eastman Kodak Co., Rochester 10, N.Y.

Pierre Mertz, Bell Telephone Labs., Inc., 463 West St., New York 14

James Middlebrooks, American Broadcasting Co., 30 Rockefeller Plaza, New York 20

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Edward Schmidt, Reeves Soundcraft, 10 E. 52 St., New York 22

N. L. Simmons, Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38, Calif.

S. P. Solow, Consolidated Film Industries, Inc., 959 Seward St., Hollywood 38, Calif.

J. G. Stott, Du-Art Film Laboratories, 245 W. 55 St., New York 19

W. L. Tesch, Radio Corporation of America, RCA Victor Div., Front and Cooper Sts., Camden, N.J.

S. R. Todd, Consulting Electrical Engineer, 4711 Woodlawn Ave., Chicago, Ill.

M. G. Townsley, Bell & Howell, 7100 McCormick Rd., Chicago 45, Ill.

Discussions in the Journal

Discussions are a valuable part of the Society's functioning. Those which occur on the floor at Conventions are now recorded as described in Ed Templin's Committee Report in the December *Journal*. The procedure and policy, once discussion is on a disk, are:

Headquarters staff transcribes it almost verbatim, pausing to correct only the most obvious verbal slips. The typewritten transcript is sent to the author, usually at the time his paper is being processed for *Journal* publication. Depending on the length and clarity of the discussion, the transcript is sent simultaneously or successively to all discussers. Whatever the timing, however, **discussion is sent to all persons named in the record and they must clear it before it is published.** What worthy discussion cannot be identified as to source becomes that of Mr. Anon.

Within a month after the close of the Hollywood Convention, the Society's staff had transcribed 105 pages of discussion from that program.

In addition, 48 pp. have been transcribed and mimeographed as the record of the Panel Discussion on Emulsion Position of 16Mm Positives. This has been sent to all known interested persons. Let headquarters know if you are interested and were overlooked. A copy will be sent to you. When everyone interested has returned his panel or subsequent discussions to Society headquarters, a composite copy will be made for review by Norwood Simmons, who was moderator of the panel discussion, and it will then be assessed for *Journal* publication.

Engineering Activities

Three meetings of interest were held recently, only one of a Society engineering committee. The highlights of these meetings are outlined below.

PH22 Led by its new Chairman, D. R. White, ASA Sectional Committee on Standards for Motion Pictures, PH22, met November 29, 1951, and had a very fruitful session with an agenda limited to three key items.

Letter Ballots: Three letter ballots were considered and acted upon:

1. Two proposed standards for 35mm multifrequency test films, PH22.63 and PH22.64, held in abeyance for some time as a result of a major consumer's negative vote, were returned to the Sponsor for resolution of the existing differences.
2. A proposed revision of the standard for 16mm reels, PH22.11, was approved and forwarded to the Sponsor.
3. The ballot on the 16Mm Edge Numbering Proposal, PH22.83, was incomplete and the Chairman was authorized to close the ballot at his own discretion.

ISO: Questions relating to a contemplated meeting of ISO TC/36 (International Standards Organization Technical Committee on Cinematography) in New York in June 1952 were thoroughly reviewed. It was decided to canvass the participating members concerning their interest in attending such a meeting, informing them of our willingness to call one if there is promised attendance from abroad. (The ASA, Secretariat of TC/36, subsequently sent a modified version of a letter drafted by PH22.)

PH22 Scope: The new scope, endorsed at the last meeting, was criticized in the interim as excessively broad and two alternate proposals were offered for Committee consideration. A compromise between the two was approved as the Committee recommendation to the SMPTE, which as Sponsor, has the final word on the scope to be submitted to the ASA.

IRS The IRS was formed in April 1950 as a coordinating committee of three Societies (IRE, RTMA, SMPTE) to eliminate or reduce duplication of work and areas of conflict in mutual spheres of activity, primarily in the field of television. Originally chaired by Axel Jensen and now by Fred Bowditch, the Committee met November 30 and December 20, 1951, to consider two main points.

Committee Addition: In the light of NARTB's renewed interest in standards activity, discussions were held as to the advisability of including it as a fourth member. After an affirmative vote at the first meeting, the NARTB was officially welcomed as a Committee member at the December meeting.

Recording Standards: CCIR's (International Radio Consultative Committee) program for standardizing radio program recordings for use between nations was outlined and the need for American Standards on sound recording was reviewed. The Committee concluded that the ASA Sectional Committee on Sound Recording, Z57, should be reactivated and proposed the procedure for achieving this.

New Name: The addition of a fourth member required a change in the IRS Committee name which was compounded from the first initials of the three participating Societies. "Joint Committee for Inter-Society Coordination," to be abbreviated "JCIC," won the day and is the new name of the Committee.

Television Studio Lighting Since its inception in January 1950 under the chairmanship of Richard Blount, this Committee has met about every three months. The Chairman noted, however, that very little has been accomplished this past year. The main discussion then centered on the cause of this situation and how to remedy it.

This very practical approach resulted in changes both in form and content of the Committee's work with accompanying changes in project responsibilities. Small subcommittees were eliminated and the entire Committee is to concentrate its attention on two main projects: lighting measurements and terminology.—*Henry Kogel,* Staff Engineer.

Book Reviews

Three-Dimensional Photography: The Principles of Stereoscopy

By Herbert C. McKay. Published (1951) by American Photographic Publishing Co., 421 Fifth Ave. So., Minneapolis 15, Minn. 334 pp. 98 illus. 6 × 9 in. Price $5.75.

Herbert C. McKay, FRPS, ASC, well known to readers of *American Photography* for his monthly column "Notes from the Laboratory" and for his observations on developments in photography and comments on stereoscopy, has compiled a text that is of interest to amateur photographers but it's hardly a book that has much appeal to professional photographers or serious stereographers. Some of the theories on which the principles of stereoscopy are based are blithely ignored, some are attacked. It certainly is not to be recommended as a reference work for any motion picture engineer interested in the stereoscopic process.

The author preaches such adroit doctrines as: "It has been repeatedly demonstrated that a beginner knowing nothing whatsoever about photography will have a greater success in stereo than in conventional photography"; and " . . . the fact remains that the gravest trouble encountered by projectionists in the stereo field is the result of taking too much care."

The inference, to me at any rate, is that knowledge of stereoscopic theory, skill in photography, and careful craftsmanship are handicaps rather than helps in the stereoscopic art.

To sustain the mood, the author, in referring to the projection of stereo slides has this to say, " . . . You drop the stereogram in the projector and enjoy it. The headaches have all been removed. There is nothing more than this that is absolutely essential." Then, in taking stereograms of close objects, "Some stereographers erroneously use a narrow base when making any stereogram nearer than ten feet."

He evidently means that if you're photographing a flower at a distance of 2½ ft with the normal base (lens interaxial) of 2½ in. and there is not provision on the camera for converging the field of each lens to a plane 2½ ft away or nearer you'll come out with a perfectly good stereogram. This conflicts with some of the basic theories of stereoscopy.

To quote the author again: "Those who have seen modern stereo projection, now predict that stereo movies will soon be developed; they do not know that stereo movies were presented in a Broadway theatre a quarter century ago, and in many other theatres throughout the land. They do not know that polarized light stereo movies were featured at both the Chicago (1933) and New York (1939) World's Fairs. There is little to be done in that field, it has all been done time after time and any amateur can with a minimum of ingenuity make his own stereo attachments which will enable him to project perfect stereo movies." It will interest all to know that "There is little to be done in that field, it has all been done time after time . . . . " And, that anyone with a minimum of ingenuity can make and project *perfect stereo movies*. I'm afraid it takes just a bit more doing than Mr. McKay seems to indicate.

But let's have some more light on the subject from the author: " . . . we have not emphasized the distinction between motion pictures and still projection, for one very good reason. Optical projection remains the same no matter whether the projected images are changed twenty times a second or twenty times an hour. A system which will work with one, will, with few exceptions work with the other." This reviewer and his associates have been concentrating through the years on these "few exceptions," to the exclusion of the seemingly more direct and simpler methods. All serious workers in cinestereoscopy must take into consideration the problems of uneven illumination, differential vibration between members of the stereoscopic pair and other things that can detract from complete visual comfort for the audience viewing three-dimensional motion pictures.—*J. A. Norling*, Loucks and Norling Studios, 245 W. 55th St., New York 19.

The Indian Film

By Panna Shah. Published by I. K. Menon and the Motion Picture Society of India, Sandhurst Bldg., Sandhurst Road, Bombay 4, India. 289 pp. incl. 22 pp. of appendix, bibliography and index. 20 illus. 5½ × 8½ in. Price Rs. 10/-.

Dr. Panna Shah has put film makers both of the East and the West very much in her debt by this searching study of the conditions of the motion picture industry in her native country. Thoroughly versed in the film literature of the western world, Dr. Shah has a useful yardstick for measuring Indian accomplishments. The conditions she reveals are indeed depressing. In chapter after chapter she castigates Indian producers, distributors and exhibitors alike for the poor quality of Indian films and the wretched conditions under which they are shown. Yet her criticisms are not merely destructive. It is evident that they are inspired by a strong and sincere wish to see indigenous Indian films of high quality achieve success in India itself and spread a greater knowledge of India to the rest of the world.

Though vital statistics of the Indian industry are seemingly scanty and inaccurate, Dr. Shah collates them to the best possible effect to show a state of affairs resembling that of the U.S. industry some thirty years ago, when bankruptcies, ever-changing amalgamations and sudden standstills of production were prevalent. Nor are these conditions surprising in a country where so high a proportion of the population lives in the villages, which are seldom or never reached by films. And there are the further limitations of multiplicity of languages and tremendous differences of taste and cultural background.

The history of the Indian film is thoroughly covered, and there are chapters on Indian film stars, on audiences, on censorship, on mythology, and on the social influence of films, which is evidently the author's particular field of study. This is a book which all should read who wish to learn more about the second largest film industry in the world.—*Raymond Spottiswoode*, Kingsgate, Sudbury Hill, Harrow-on-the-Hill, Middlesex, England.

The Film Industry in Six European Countries

By Film Centre, London. Published (1950) by Unesco, Paris; U.S. sales agent, Columbia University Press, 2960 Broadway, New York 27. 156 pp. Many tables. 5⅞ × 8⅞. Paper covered. Price $0.65.

This is one of the series "Press, Film and Radio in the World Today" which Unesco is publishing in following out its constitutional obligation to "further by all possible means the use of the instruments of mass communications in the work of advancing the mutual knowledge and understandings of peoples."

Beginning on the strong basis of a Danish report "Betaenkning . . . angaende Biografvaesenet" published in 1950, a detailed study and comparison are developed for the other two small countries, Norway and Sweden, then chiefly a statistical study is presented for Italy, France and the United Kingdom. Making Denmark the special part of this study is logical enough when the facts are in on the Danish film industry: for instance, Denmark a country of only about 4,000,000 persons produces more films a year than Belgium, The Netherlands and Switzerland together. This small book has an amazingly large amount of text and statistics about costs and results in exhibition, distribution and production.—V.A.

Charlie Chaplin

By Theodore Huff. Published (1951) by Henry Schuman, 20 E. 70th St., New York 21. i-xi + 354 pp. + 80 pp. illus. 6 × 9 in. Price $4.50.

The filmic Charlie Chaplin is here given perhaps as well as he can now be portrayed in a book, unless a book were to contain even more than this volume's generous collection of 80 pages of illustrations. But of looking at stills there is soon an end, and we go back whenever possible, generation after generation the world over, to seeing Chaplin films. And how seldom we hear them referred to nowadays as "old" films.

For the many who would like to find out how old is each Chaplin film, this is an excellent reference. One appendix

gives biographical sketches of the people professionally associated with Chaplin; another appendix indexes thoroughly all the films: the Keystones in 1914, the Essanay Films of 1915–16, Mutual Films in 1916–17, the First National releases of 1918–22, and the seven released by United Artists in 1923–1947. Casts, release dates, length of films and other data are given.

There is considerable text which will varyingly inform or interest readers. Not only is the production of each film described but also there is given a frame of timely reference of general and film business conditions, international and domestic political factors, and, without being unnecessarily scandalous about it, an adequate notice of what was happening in the personal lives of those on or off the sets. If this is not a thoroughly knit and compact picture of the individual Chaplin, perhaps we can forgive the biographer at this time when it is doubtful if such could be accomplished even autobiographically. On one point, however, the author is clear: the artist Chaplin has ever been striving wholly and honestly to accomplish more and more with the film, to make each film somehow a greater accomplishment than the preceding one.

That Chaplin's success has been continual and consistent may properly be doubted by biographer and reader according to his own artistic taste. This book gives a solid basis for our understanding the peculiar qualities of Chaplin and his use of the film medium which led George Bernard Shaw to call Chaplin "the only genius in motion pictures."—V.A.

The Little Fellow

The Life and Work of Charlie Chaplin

By Peter Cotes and Thelma Niklaus. Published (1951) by Philosophical Library, 15 E. 40th St., New York 16. 160 pp. incl. 32 pp. illus. $5\frac{1}{4} \times 8\frac{3}{4}$. Price $3.75.

There is less about motion pictures in this book than in the book briefly reviewed above. There is much more of an effort by the coauthors to accomplish a psychological analysis of Chaplin's background, development and work. There is a deal of detail beginning generally with Chaplin's efforts to earn his way at the age of eight, then on through his growing artistic and financial successes. At the age of 11 he successfully achieved the part of Billy in *Sherlock Holmes* only by having his mother drill him with the script, for he had not yet learned to read or write.

The authors seem fairly occupied in setting consistently right the considerable record of matrimonial matters, of which the public may have an undue aftertaste from many doses of strong headlines and lurid inks. The explanations of why Chaplin's first three marriages were ill fated and his present one apparently the contrary are plausible and interesting enough; but the authors do not quite explain how anyone, genius or otherwise, could often create such unbelievably bad working conditions for himself and then accomplish the almost superhuman in completing the motion picture he wanted — but at other times to be the effective genius from the start in training and directing as in *The Kid*.—V.A.

Acoustical Terminology is American Standard Z24.1–1951 sponsored by the Acoustical Society of America in cooperation with The Institute of Radio Engineers. This latest edition was approved July 31, 1951, and is now available at $1.50 from the American Standards Assn., 70 E. 45th St., New York 17. A number of special committees worked to revise this standard since the first edition was published in 1942. The section on speech and hearing has been thoroughly revised to bring it into agreement with the most recent experimental results. Twelve sections, including six tables, and a thorough index make up this 50-page standard.

John Wiley & Sons, Inc., is revising its mailing lists and would appreciate receiving a postal with the proper address and an indication of your interest in scientific, technical or business books. Address: Miss Clotilda Lowell, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Archer, Nicholas M., University of Southern California. **Mail:** 5965¼ Chula Vista Way, Hollywood 28, Calif. (**S**)

Conner, Robert W., Director of Engineering, KLAC, KLAC-TV, 1000 Cahuenga Blvd., Hollywood, Calif. (**M**)

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Jewell, F. Irving, Director, Visual Education, National Council, Boy Scouts of America, 2 Park Ave., New York, N.Y. (**A**)

Kook, Edward F., President, Century Lighting, Inc., 521 West 43 St., New York, N.Y. (**M**)

Litecky, Paul A., Photographer, Cinematographer. **Mail:** 1306 Davis Ave., Whiting, Ind. (**A**)

Morris, Thomas C., Camera Operator, Jerry Fairbanks. **Mail:** 10552 Tinker Ave., Tujunga, Calif. (**A**)

Pierce, Cameron G., Television Engineer, American Broadcasting Co. **Mail:** 555 Old Mill Rd., San Marino, Calif. (**M**)

Pon, S., Salesman. **Mail:** Corner Best & Victoria Roads, Sophiatown, Johannesburg, South Africa. (**A**)

Reisinger, Carl H., Photographer, Freelance. **Mail:** 1417 Kalmia Rd., N.W., Washington, D.C. (**A**)

Rothenberger, Warren Jack, First Cameraman, Boy Scouts of America. **Mail:** 1543 Sidney Pl., East Meadow, L.I., N.Y. (**A**)

Spriestersbach, Charles L., Television Technician, KTTV. **Mail:** 15117 Germain St., San Fernando, Calif. (**A**)

CHANGES IN GRADE

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Denney, Bruce H., Sound Engineer, Paramount Pictures Corp. **Mail:** 418 North Highland Ave., Los Angeles 38, Calif. (**A**) to (**M**)

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Melvin L. Stewart is the designer of the Society's new emblem which was adopted by the Board of Governors last October and described in the December *Journal*. The symbol appears on the cover of this issue of the *Journal* and it will gradually be made a part of the many Society communications. Mr. Stewart resides at 10326 Orton Ave., Los Angeles. He is a senior commercial design student at the University of Southern California, ranks high in his class and has received three scholarship awards. He has exhibited magazine cover designs, book jacket, fabric and wallpaper designs. He is 23 years of age and is the son of George M. Stewart who is employed in the Sound Department of Twentieth Century-Fox Film Corp., Beverly Hills, Calif.

New Membership Directory

A new directory will be mailed as Part II of one of the *Journals* late this spring. Plans are to organize it generally as was done in 1950 — unless members send in valid suggestions for a revised arrangement.

Each member should note that with his statement for dues for 1952 the Society sent a copy of his last listing brought up to date according to the Society's records at the beginning of December. In making the new directory, advice about changes in address or employment will be taken into account at least as late as March 3.

Meetings of Other Societies

American Physical Society, Annual Meeting, Jan. 31–Feb. 2, Columbia University, New York

Inter-Society Color Council, Annual Meeting, Feb. 7–9, Hotel Statler, New York

I.R.E. National Convention, Radio Engineering Show, Mar. 3–6, Hotel Waldorf Astoria and Grand Central Palace, New York

National Electrical Manufacturers Association, Mar. 10–13, Edgewater Beach Hotel, Chicago, Ill.

American Physical Society, Mar. 20–22, Columbus, Ohio

Optical Society of America, Mar. 20–22, Hotel Statler, New York

American Physical Society, May 1–3, Washington, D.C.

Acoustical Society of America, May 8–10, New York

American Institute of Electrical Engineers, Summer General Meeting, June 23–27, Hotel Nicollet, Minneapolis, Minn.

American Physical Society, June 30–July 3, Denver, Colo.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

Illuminating Engineering Society, National Technical Conference, Aug. 27–30, Washington, D.C.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.

The Aminco Photomultiplier Microphotometer is a product of American Instrument Company, Inc., Silver Spring Md., designed for many applications including film densitometry. This instrument has ranges providing direct readings for intensities from 20 micromicrolumens to 20 lumens, densities from 0 to 9 and phototube currents from 10^{-5} to 10^{-11} amp which can be extended with neutral filters.

Full-scale deflection of the meter is given with photomultiplier (or phototube) currents of 10, 1, 0.1 and 0.01 μa. The latter value corresponds to a sensitivity of 20 micromicrolumens per meter division with photomultiplier tube detector No. 4-6250 which is supplied with the instrument. Commercial types of phototubes (blue, green, red and infrared) may be used by wiring them into an 11-prong base.

The American Instrument Company reports that it will supply filters from Baird, Bausch & Lomb, Corning, Eastman, Farrand or Fish-Schurman, which are 2 in. (50 mm) square and may be positioned in the filter holder, either singly or in combinations up to $\frac{3}{8}$ in. thick.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April 1951 *Journal.*

A new professional camera dolly that will go through most standard doorways without being disassembled is being marketed by The Camera Mart, Inc., 70 W. 45th St., New York 19, under the trade name TV Camera Car. Equally useful in the motion picture industry, the Camera Car weighs 350 lb, is 30 in. wide, and provides lens angles from 26 in. to seven ft.

The dolly carries the cameraman and one assistant, and one man can maneuver it, either on or off dolly tracks. The two front wheels are set and the two rear wheels have an auto-linkage steering mechanism for maneuverability or sharp turns. Two floor locks steady the dolly for set shots, and boom arm braces are designed to prevent vibrations for extended dolly runs. The tripod head has two leveling finger-tip jacks for quick horizontal adjustment. In addition there is a vertical leveling rod attached to the boom arm, a necessity when setting for a side shot.

Four powerful removable springs and a cable are arranged to balance any weight camera and blimp. Raising or lowering the boom arm is accomplished by turning the large counter-balanced wheel and attached gears. The dolly is constructed of aluminum alloy castings with bridge supports for greater strength and flexibility, and with 10-in. ball-bearing rubber-tired wheels.

With the boom in a horizontal position, the dolly may be lifted into a station wagon for easy transportation. In addition, in 20 min it may be disassembled into its three main parts and carried on a location where the areas are too confined to admit it otherwise. Reassembling then takes approximately 30 min. This is considered an especially valuable feature when shooting on locations in old buildings with narrow stairways or no elevators. The Camera Car is priced at $1,495 FOB New York.

Westrex 1100 Series Magnetic Recording System

Correction and amplification: Running back to the November 1951 *Journal*, p. 510, we should now record that the above illustrates the 1100 Series Portable Magnetic System now being introduced to the industry by Westrex Corporation. The rest of the record is now played back for your convenience:

The 1100 Series Portable Magnetic System now being introduced to the industry is a direct outgrowth of field experience with the earlier 1000 Series System previously described in the *Journal* for March 1951. The number of cases has been reduced to two as shown in the photograph, the two-position mixer being on the right and the recorder being on the left. The latter houses, in addition to the film pulling mechanism, the a-c power supply for the channel, the bias oscillator and the film monitor amplifier.

New features of this system include two-way talkback equipment between the mixer and recordist, a talkback amplifier being provided in the recorder housing. Another new feature is a synchronizing bloop unit which records an audible signal when the recorder is up to speed on the magnetic film in synchronism with an optical bloop in the associated photographic camera.

The system operates from 115 v, single-phase, 50- or 60-cycle a-c supply, provision being also made for motor operation from 220 v, 3-phase, interlock or multi-duty motor systems. Runback at normal speed is provided. The power drain for the electronic components is somewhat less than 100 w and a 2-amp drain at 115 v is required for the single phase motor supply.

The weight of the complete system, including cables, is approximately 170 lb. The system is available for 35mm, 17½mm or 16mm operation. The track positions are in accordance with the proposed ASA magnetic track standards for 35mm and 16mm films. The recorder may also be used as a magnetic film reproducer, equalization being provided in the playback amplifier to give an essentially flat response from 50 to 8000 cycles when operating at 90 ft/min. By incorporating some pre-emphasis in recording on 16mm film, a flat response to 6000 cycles may be obtained at the 16mm speed of 36 ft/min.

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